VANASPATI INDUSTRY

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(2) vegetable oil products
(3) Indian vanaspati industry
(4) hydrogenation
(5) hydrogenated oils
(6) production control

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THE VANASPATI INDUSTRY

GOPAL S. HATTIANGDI, M.Sc., Ph.D., F.R.I.C.

The Hindustan Vanaspati Manufacturing Company (Private) Limited,
Bombay.

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Foreword

At the Ninth Annual General Meeting of the Indian Central Oilseeds Committee held at Hyderabad on the 22nd October, 1955, I proposed that the Committee should bring out a series of monographs on oilseed crops and allied industries. One of the subjects selected was "The Vanaspati Industry" which was assigned to Dr. G. S. Hattiangdi of The Hindustan Vanaspati Manufacturing Company Private Limited, Bombay (now Hindustan Lever Limited). I am glad that Dr. Hattiangdi has been able to compile the monograph which has involved a good deal of patient and hard work.

The refined hydrogenated vegetable oil which is known as "vanaspati" is in considerable demand on account of the shortage in ghee production. This demand rose very early and, in 1928-29, 23,000 tons of vanaspati were imported into India. To meet this demand the first vanaspati factory was established in India in 1930. There are now 58 factories with a capital investment of about 20 crores of rupees and an annual production capacity of about 4·5 lakh tons.

Now that the manufacture of vanaspati occupies an important place in the food economy of India, I am glad that a monograph on this subject has been compiled by Dr. Hattiangdi. I hope it will be of use to all who are interested in the manufacture of vanaspati. Dr. N. G. Chatterji, the general editor for the technological series of monographs of the Indian Central Oilseeds Committee, has carefully revised the manuscript. Shri N. S. Bisht, Director of Art, Indian Council of Agricultural Research, has prepared the lay-out of illustrations. Dr. R. Sankaran, Secretary of the Indian Central Oilseeds Committee, has taken a good deal of interest in the work relating to the monographs and I am glad that on account of his strenuous efforts this programme has been implemented.

M. S. Randhawa, D.Sc., F. N.I., I.C.S.
Vice-President, Indian Council of Agricultural Research,
Additional Secretary to the Government of India,
Ministry of Food and Agriculture,(Department of Agriculture)
and
President, Indian Central Oilseeds Committee.

New Delhi,
2nd December, 1957.

Acknowledgments

The author wishes to express his grateful thanks to the President of the Indian Central Oilseeds Committee for inviting him to write this monograph ; to the Council of Scientific and Industrial Research, the Indian Standards Institution and the Vanaspati Manufacturers' Association of India for providing much useful information and statistical data; to Messrs. Tata Oil Mills Company Limited, Bombay, for providing information regarding the use of the Votator ; to Messrs. Indian Vegetable Products Limited, Kusum Products Limited, Swastik Oil Mills Limited and Tata Oil Mills Company Limited for permission to publish photographs of their plant; to Messrs. Lintas Limited, Bombay, for providing a substantial portion of the art work; to Mr. F. Wiesinger of the Examiner Press, Bombay, for his kind co-operation; and to the Directors of Messrs. The Hindustan Vanaspati Manufacturing Company Private Limited, Bombay, for their kind permission to produce this monograph.

Bombay,
April 1956.

The Author.

CHAPTER I

VEGETABLE OIL PRODUCTS

(a) Production and Utilisation of Vegetable Oils

India is one of the leading oilseed producing countries in the world, and it produces in commercial quantities a wider variety of oilseeds than any other country. With the exception of palm, palm kernel, olive, soya bean, sunflower and tung oils, India produces all the other principal oilseeds which form the basis of the seed-crushing industry. India holds this unique position chiefly by virtue of the fact that this vast sub-continent possesses a large variety of soils and climatic conditions which favour the cultivation of a variety of oilseed crops over extensive areas in different parts of the country, there being more than one crop per season in respect of certain items. The prominent place which the oilseed crops occupy in the agricultural economy of the country can be gauged from the fact that about 9 per cent of the total area under cultivation, that is about 30 million acres, is devoted to the production of the major oilseed crops which constitute about 17 per cent of the world's production.

The principal oilseeds produced in India are groundnut, rape, mustard, *sesame*, linseed, castor, cottonseed and copra. In addition to these oil-bearing seeds which are produced on a large scale, there are numerous seeds, like nigerseed, safflower (*kardi*), tobacco seed and poppy seed, which are produced in comparatively smaller quantities, and many others, such as *mowrah*, *neem* and *karanja*, which are obtained from trees which grow wild in various parts of the country. Very little authentic data are available in respect of the production of these minor oil-bearing seeds. Table 1 gives the production figures for some of the major oilseeds in India and in the world during 1953 or 1954-55.

Table 1: Production of Oilseeds

Seed	Production (tons) in	
	World	India
Castor	452,000*	107,000
Copra	2,691,000	190,000
Cottonseed	15,121,000	1,377,000
Groundnut (unshelled)	10,889,000	3,772,000
Linseed	3,035,000	355,000
Rape and mustard	4,764,000@	826,000
Sesame	1,931,000	531,000

* Excluding U.S.S.R., Eastern Europe and China. @ Excluding U.S.S.R.

The crushing of oilseeds has been practised in India since time immemorial with the use of a bullock-driven *ghani*. The large scale crushing of oilseeds with modern appliances was started after the end of World War I, and this was reflected in the gradual decline of the export of seeds, such as, groundnut, linseed, castor and *sesame*. World War II gave a further impetus to the oil milling industry in India with the result that almost the entire crop is now crushed within the country, except, of course, the hand-picked groundnut seeds which are exported for special edible uses.

Table 2: Average Annual Exports of Oilseeds, Oils and Cake from India

Average annual exports during the quinquennial period	Oilseeds (tons)	Oils (tons)	Cake (tons)
1909-14	1,443,000	16,600	140,000
1914-19	700,000	28,300	117,000
1919-24	914,000	14,500	136,000
1924-29	1,182,600	6,100	245,200
1929-34	1,010,000	8,200	278,400
1934-39	922,400	7,100	357,200
1939-44	541,000	16,300	96,000
1944-49	203,000	32,500	800
1949-54	124,600	91,100	3,500

The present oil milling industry in India may be categorised under the following three groups :

(a) Cottage industry, using bullock-driven *ghanis* or similar other indigenous manually-operated or animal-driven appliances ;

(b) Small oil mills, using power-driven *ghanis* ; and

(c) Large oil mills, which are registered under the Factories Act, and which are equipped with modern appliances such as presses, expellers and solvent extraction units.

There are no reliable data regarding the first two groups, but it is estimated that there are about 450,000 *ghanis* scattered throughout the country which crush about 700,000 tons of seed per annum, and about 3,500 small mills which crush a further 700,000 tons per annum. Of the large oil mills, there are about 1,000 in number and these crush nearly 1,200,000 tons of seed per annu m

The Government of India have so far permitted 25 projects for the establishment of solvent extraction plants. These are in different stages of development but should eventually be able to extract oil from about 800,000 tons of cake per annum. Three of these units were working in 1954, and the total quantity of oil recovered was 2,000 tons.

The actual data pertaining to the supply and utilisation of the major oils during 1955 are not yet available, but the estimated figures are given in Table 3. It will be observed that the consumption of refined oils is very low but fairly large quantities of crude unrefined oils are used in India for edible purposes. For example, rape-mustard oils are very popular cooking media in Uttar Pradesh, Bengal and Bihar ; *sesame* and coconut oils in Madras and other parts of South India ; and groundnut and safflower oils in Bombay, Madhya Pradesh and Hyderabad.

In 1952, the Indian Standards Institution undertook the task of preparing specifications for some of the major oils produced in this country,

Table 3: Supply and Utilisation of Vegetable Oils in India During 1955

(All figures rounded off to the nearest hundred and expressed in English tons)

Item	Coconut Oil	Cottonseed Oil	Groundnut Oil	Linseed Oil	Mustard & Rape Oils	Sesame Oil
Production	158,100	12,500	922,900	118,500	264,400	161,000
Imports	25,000	—	—	—	—	—
Exports	—	5,800	140,000	71,000	500	—
Supply available	183,100	6,700	782,900	47,500	263,900	161,000
Utilisation :						
(*a*) For edible purposes as crude unrefined oils ..	81,600	—	450,400	7,500	263,900	123,000
(*b*) For edible purposes as hydrogenated or refined oils	—	500	280,000	—	—	18,000
(*c*) For non-edible purposes ..	101,500	6,200	52,500	40,000	—	20,000

Table 4: Indian Standard Specifications for some Indian Vegetable Oils

Oil	I.S.S. No.	Saponification value	Iodine value	Acid value (max.)	Unsaponifiable matter (%) (max.)	Specific gravity @30°/30°C	Refractive Index @ 40°C
Coconut (Grade 3) ..	542-1954	Min. 250	7·5-10·0	10·0	0·8	0·915 to 0·920	1·4480 to 1·4490
Cottonseed (Washed) ..	543-1954	190-198	105-112	0·5	1·5	0·910 to 0·920	1·4645 to 1·4660
Groundnut (Grade 3) ..	544-1954	188-195	87-98	10·0	1·0	0·909 to 0·913	1·4620 to 1·4640
Linseed (Raw) ..	75-1950	188-195	Min. 175	4·0	1·5	0·923 to 0·928	1·4720 to 1·4750
Mustard (Grade 2) ..	546-1954	172-177	98-108	4·0	1·2	0·907 to 0·910	1·4650 to 1·4670
Sesame (Grade 2) ..	547-1954	188-193	105-115	6·0	1·5	0·915 to 0·919	1·4645 to 1·4665

and some of the analytical characteristics prescribed by them are summarised in Table 4. These specifications relate to oils obtained by the process of expression only. In respect of solvent extracted oils, the Indian Standards Institution have decided to defer the question of preparing standard specifications until such time as more data on the subject become available.

(b) Hydrogenated Vegetable Oil Products

During the early part of this century, India used to supply oilseeds and oils to various European countries, and ghee and vegetable oils were the locally accepted cooking media. In the last few decades, the population of India increased considerably and this brought about a corresponding increase in the domestic requirements of oils and fats. The production of wholesome edible fats, such as ghee, could not keep pace with these changes with the result that the prices rose beyond the economic reach of many prospective consumers. As in Europe during the 19th century, so in India during the current century, the shortage of edible fats was aggravated by growing industrialisation which drew a large proportion of the population away from the land. To fulfil their needs, the people found an acceptable alternative to ghee in the form of hydrogenated oils. It was thus that the vanaspati industry was born in India, to offer to the traditional ghee consumers a relatively inexpensive fat of similar consistency to butter fat, and to the traditional consumers of particular kinds of vegetable oils, a refined oil in a different form.

Vanaspati is vegetable oil which has been refined, hydrogenated, deodorised and vitaminised. Refining removes the objectionable slime, dirt, free fatty acids and colour which are always present in crude vegetable oils. Hydrogenation changes the liquid oil into a plastic fat and, at the same time, it improves the keeping properties of the oil. Deodorisation removes the malodorous and unpalatable constituents which crude vegetable oils always contain. Packing in hygienic containers ensures that the product reaches the market in the same fresh, uncontaminated and unadulterated state in which it left the factory.

(c) Review of the Vanaspati Industry in India

It is not clear how the term "Vanaspati"* originated. It was perhaps evolved to emphasise the vegetable origin of the product as opposed to the animal origin of its more familiar counterpart, ghee. The term is now well accepted and used throughout the length and breadth of the country to mean

* In Sanskrit, *vana* = forest ; *pati* = lord ; hence, literally, *vanaspati* = lord of the forest. Thus, a tree or plant ; vegetable.

PLATE I: GENERAL VIEW OF A VANASPATI FACTORY

(The Hindustan Vanaspati Manufacturing Company Private Limited, Bombay)

The vanaspati industry is the second largest food processing industry in India, second only to the sugar industry. It is the largest of its kind in Asia, and the fifth largest in the world. Nearly Rs. 20 crores are invested in this industry which provides employment directly to about 10,000 people and a much larger number indirectly.

(d) The Vegetable Oil Products Control Order

Prior to 1947, there was no centrally administered law controlling the manufacture and quality of vanaspati. Some of the then Provinces had prescribed standards for vanaspati in their Food Rules, but they were apparently not being enforced strictly. During World War II, the production of vanaspati increased at a phenomenal rate, and a large proportion of the manufactured product was supplied to the Defence Services. In the post-war period, there was considerable agitation in the country against the use of vanaspati. The chief arguments advanced against the consumption of vanaspati were that the product was nutritionally deficient and harmful to health, and that the product was used mainly for adulterating ghee thereby impeding the growth of the ghee and dairy industries. In order to control effectively the manufacture, stock and sale of vanaspati, the Government of India formulated in 1947 what is now well-known as the Vegetable Oil Products Control Order. This Order was promulgated on the 9th August 1947 under the Essential Supplies (Temporary Powers) Act, 1946. The life of the latter Act was limited to the 26th January 1955 and, with effect from that date, the Vegetable Oil Products Control Order is enforced under the Essential Commodities Act, 1955. The text of the Vegetable Oil Products Control Order, as amended upto 31st December 1955, is given in Appendix C.

In these specifications, a maximum limit for the melting point of vanaspati has been prescribed at 37°C ; as this is almost identical with the body temperature, the product is easily digested and assimilated in the body. The incorporation of vitamin A at the level of 700 International Units per ounce of vanaspati is compulsory, which makes the product as rich a source of this vitamin as good cow ghee. The addition of 5 per cent *sesame* oil is also compulsory, and the inclusion of this oil permits the easy detection of the adulteration of ghee with vanaspati ; if vanaspati is present in ghee, the product will respond to the Baudouin colour reaction, a very sensitive test which is specific for *sesame* oil only. It will thus be seen that the specifications given in the Vegetable Oil Products Control Order have been so prescribed that the arguments advanced against the nutritional deficiency of vanaspati have been adequately answered, and the detection of the adulteration of ghee with vanaspati is simplified.

(e) The Vanaspati Manufacturers' Association of India

The Vanaspati Manufacturers' Association of India came into existence in July 1939 and became a formal body on the 18th June 1946, on which date its constitution was adopted. The membership of the Association is open to any person, firm or company who is engaged in the business of manufacturing vanaspati in India or who, with a view to manufacturing vanaspati in India, has placed orders for the necessary plant and machinery and/or has commenced construction of buildings necessary for the intended vanaspati factory. The Association has 15 varied aims and objectives of which the principal ones are :

(1) to promote and protect the trade, commerce, manufacture and sale of vanaspati manufactured in India ;

(2) to promote and organise scientific research calculated to advance the trade, commerce and manufacture of vanaspati and allied products;

(3) to initiate and promote with the public authorities the passage of laws, decrees or administrative regulations calculated to promote and protect the trade, commerce, manufacture and sale of vanaspati and to favour by whatever means the legitimate interest of such trade, commerce, manufacture and sale by opposing or proposing pertinent modifications in existing or projected laws, decrees and administrative regulations and for the purpose to conduct correspondence and negotiations and to make representations and to take all such proceedings, legal or otherwise, as may be necessary or expedient ;

(4) to enlighten the public on all matters relating to the trade, commerce, manufacture and sale of vanaspati and, for that purpose, disseminate information through all available media.

The Association has a chairman, a deputy chairman, a managing committee comprising of six members, and a secretary. In addition, it has two public relations officers. The Association elects representatives to a Vegetable Oil Products Advisory Committee which is appointed by the Government of India to advise the Vegetable Oil Products Controller on problems relating to the vanaspati industry in India.

CHAPTER II

HYDROGENATION OF OILS

(a) Theoretical Principles underlying Hydrogenation

Hydrogenation of oils consists in the addition of hydrogen at the double bonds in the fatty acid chains. The degree of hydrogenation of an oil is thus related directly to its iodine value, the addition of one molecule of hydrogen corresponding to the absorption of one molecule of iodine. The process of hydrogenating vegetable oils as carried out in industry is a catalytic reaction.

For hydrogenation to take place, gaseous hydrogen, liquid oil and a solid catalyst (finely divided nickel is the commonest) must be brought together at a suitable temperature. The hydrogenation of an oil is believed[29] to involve the following sequence of operations :

(1) Solution of hydrogen in the oil.

(2) Adsorption of dissolved hydrogen on the catalyst.

(3) Reaction to form a nickel-hydrogen-oil complex.

(4) Decomposition of the complex to yield hydrogenated oil and free nickel.

(5) Desorption of the hydrogenated oil.

In other words, it may be assumed that the hydrogen is first caused to dissolve in the oil, and the hydrogen-laden oil is then brought into contact with the catalyst by mechanical means. In normal industrial equipment, the entire operation consists simply of agitating the catalyst and oil in a closed vessel in an atmosphere of hydrogen. The agitation of the catalyst-oil mixture serves the double purpose of permitting the dissolution of hydrogen in the oil and also of continuously renewing the oil at the catalyst surface.

The rate at which hydrogenation proceeds depends upon the temperature, the nature of the oil, the activity of the catalyst, the concentration of the catalyst and the rate at which hydrogen and the unsaturated oil molecules are supplied at the active catalyst surface. The composition and characteristics of the resultant hydrogenated product vary according to the positions of the double bonds which are hydrogenated as well as certain isomerising

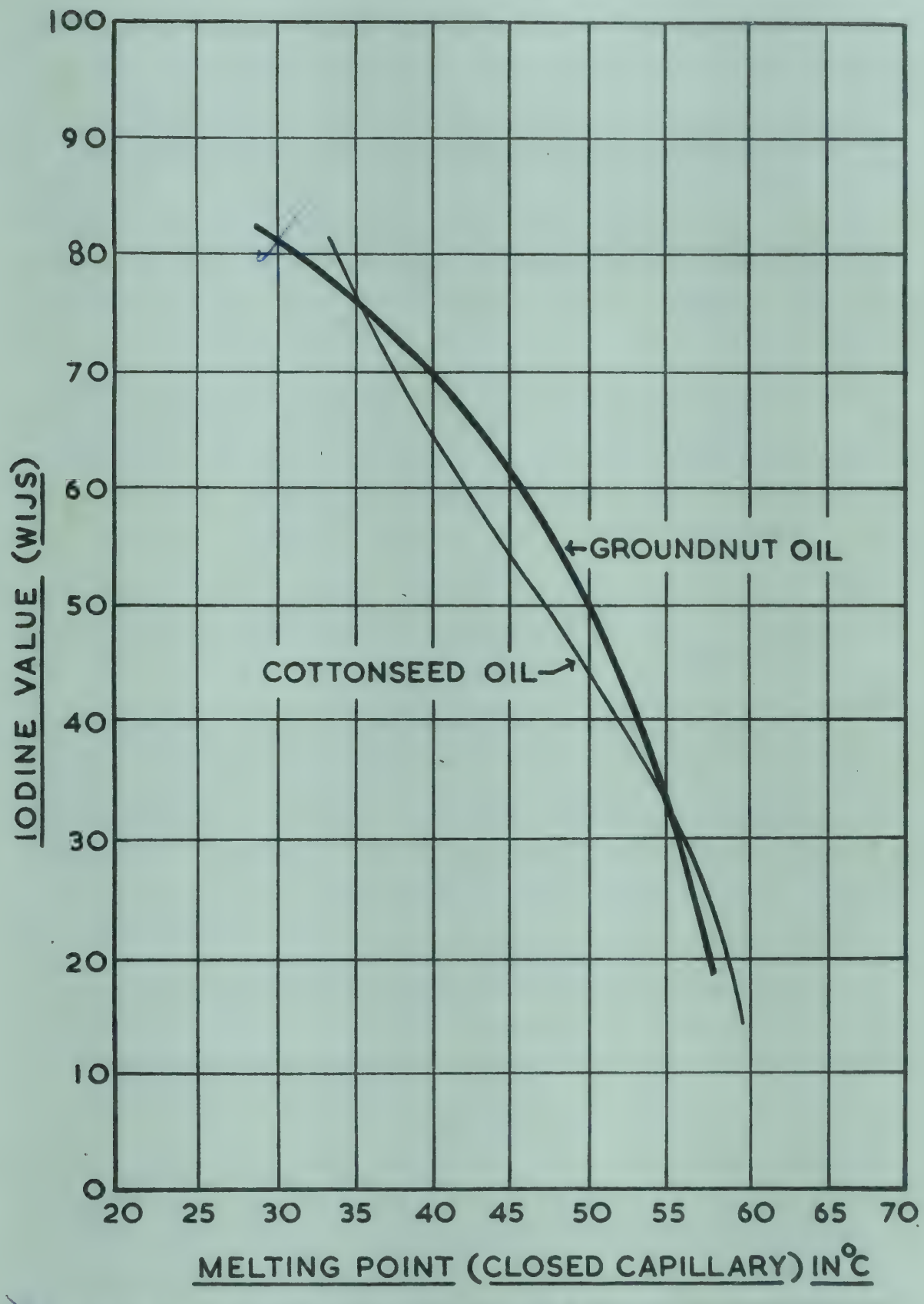

FIGURE 1 : *MELTING POINT—IODINE VALUE CURVES FOR GROUNDNUT AND COTTONSEED OILS.*

influences which accompany the reaction. The influence of the various factors on the course of hydrogenation will be considered later.

The fundamental principles underlying the different aspects of the hydrogenation reaction have been propounded by various investigators. In the case of one pure fatty acid, a mixture of fatty acids, or oils, the addition of hydrogen to the polyethenoid acids can occur either at random at any one of the double bonds or preferentially at a specific double bond; in the latter case, dehydrogenation can take place simultaneously. In the case of the hydrogenation of oils, the following views have been expressed:

(1) in a mixture of fatty acids having two, three or more double bonds, hydrogen is added first to the acid with the maximum number of double bonds; then to the acid with fewer double bonds and so forth until all the double bonds are completely saturated. Such progressive hydrogenation is called "selective";

(2) during prolonged hydrogenation at about 180°C, a considerable degree of acyl wandering takes place from one glycerol position to another;

(3) the higher molecular weight fatty acids are hydrogenated more slowly than those of lower molecular weight.

Finally, although it has not been proved conclusively, it is believed that the fatty acid attached at the β position of the glycerol molecule is less reactive than that attached at the α or α' position.

(b) Effect of Hydrogenation on Vegetable Oils

Naturally occurring vegetable oils and fats contain varying proportions of different glycerides based on saturated and unsaturated fatty acids. They do not contain any isomeric forms, but they contain impurities, such as, free fatty acids, resinous and mucilaginous substances, nitrogenous and protenacious compounds, carbohydrates, ferments and colouring matter in addition to moisture. Small traces of metallic impurities, chiefly iron, are sometimes introduced during the processing of oilseeds or the storage and transportation of vegetable oils. Almost all the aforesaid minor constituents of oils are either wholly or partially removed during the processes of degumming, alkali neutralisation and bleaching which precede hydrogenation.

During the process of hydrogenation, the degree of unsaturation is reduced and the melting point of the oil is increased (Figure 1). Depending upon the reaction conditions employed in the hydrogenation process,

small variable quantities of isomers of the unsaturated acids, broadly classified as iso-oleic acids, are formed. The melting points of some isomeric octadecenoic acids are given in Table 6.

Table 6: Melting Points of some Isomeric Octadecenoic Acids

Position of double bond	Isomeric form	Melting point (°C)	Position of double bond	Isomeric form	Melting point (°C)
2,3	cis	59	8,9	trans	53
3,4	cis	56-57	9,10	trans	43·7
4,5	cis	52-53	9,10	cis	13·4–form 16·3–form
5,6	trans	47·5	10,11	trans	42
6,7	trans	53	11,12	trans	39
6,7	cis	30	12,13	trans	39·7–40·1
7,8	trans	45·5	12,13	cis	9·8–10·4

Whereas normal (cis-form) oleic acid has a melting point of about 15°C, the corresponding trans-form (elaidic acid) has a melting point of 43·7°C. Both the cis and trans forms have an identical iodine value, but widely divergent melting points. Effectively, one can produce hardening merely by elaidinization and without any hydrogenation. The danger to this lies in the fact that the elaidinized product has an artificially increased melting point but a stability no greater than that of the original oil. In other words, from the point of view of the stability of the product it is necessary that elaidinization is reduced to a minimum.

In addition to the decrease in unsaturation and increase in hardness which are achieved during the hydrogenation process, a considerable amount of decolourising takes place simultaneously. This change is due to the reduction of the chromogenic groupings in the oil as well as to the chemical changes of certain pigments contained in the oil. For example, carotenoid pigments are bleached markedly, and this observation has led to the development of a technique of removing the colour from an oil without essentially hardening it although some reduction in iodine value cannot be avoided.

For the manufacture of vanaspati in India, the V. O. P. Controller permits ~~three~~ vegetable oils to be used, namely, groundnut, cottonseed and *sesame*. Of these, only the former two oils may be hydrogenated. *Sesame*

oil may also be hydrogenated but the minimum prescribed quantity must be only in the raw or refined state since hydrogenation reduces, or sometimes completely removes, the Baudouin colour yielding materials. The approximate fatty acid compositions of these three oils are given in Table 7.

Table 7: Approximate Fatty Acid Composition of some Oils

Fatty acid		Groundnut oil	Cottonseed oil	Sesame oil
Saturated acids	(%)	20	23	14
Oleic acid	(%)	60	33	47
Linoleic acid	(%)	20	44	39

Irrespective of whether the hydrogenation process has been selective or non-selective, a large proportion of the linoleic acid content is reduced, resulting in a corresponding increase in the saturated fatty acid content.

The effect of hydrogenation on the chemical, physical and general properties of vegetable oils may thus be summarised as follows :

(a) *Chemical:*
1. Decrease in iodine value.
2. Very slight increase in molecular weight.
3. Improvement in oxidative stability.

(b) *Physical:*
1. Increase in melting point.
2. Increase in consistency or hardness.
3. Decrease in colour.

(c) *General:*
1. Linoleic acid content reduced.
2. Iso-oleic acid introduced.
3. Possible contamination with nickel.

(c) Influence of Various Factors

Bailey *et al* [37] have studied the effect of various factors on the course of hydrogenation, and the results obtained by them are summarised in Table 8. These data may be interpreted as follows :

(1) *Effect of temperature:* Increasing the temperature leads to a greater rate of reaction and to a greater rate of diffusion of the oil molecules. Also an increase in temperature favours selective hydrogenation and the formation of iso-oleic acid.

(2) *Effect of pressure:* The greater the pressure of hydrogen, the greater is the dissolution of hydrogen in oil and hence the greater the concentration of activated hydrogen molecules on the surface of the catalyst. The result is more rapid but less selective hydrogenation.

(3) *Effect of agitation:* An increase in the rate of agitation improves the conditions of contact in the gas-oil-catalyst system, but it decreases the selective nature of hydrogenation.

(4) *Effect of the amount of catalyst:* An increase in the amount of catalyst has an influence on selective hydrogenation but it is not as great as in the case of increased temperature.

(5) *Effect of the nature of catalyst:* No positive inferences can be drawn regarding the influence of the nature of the catalyst on the hydrogenation process. There is a considerable variation in the quantity of iso-oleic acid formed, but this point cannot be directly explained.

Table 8: Influence of Various Operating Variables on the Composition of Hydrogenated Cottonseed Oil [37]

Variable	Value of variables	Hydrogenation time (minutes) to critical I.V.	Percentage composition of fatty acids at the critical iodine value of 65·7			
			Saturated	Iso-oleic	Normal oleic	Linoleic
Temperature	250°F. (121°C)	72	39·6	8·5	39·3	12·6
Temperature	300°F. (149°C)	31	34·1	11·2	47·5	7·2
Temperature	350°F. (177°C)	19	32·5	14·3	47·6	5·6
Pressure	5 lbs./sq. in., gauge	67	32·8	13·2	48·1	5·9
Pressure	27 lbs./sq. in., gauge	31	34·1	11·2	47·5	7·2
Pressure	50 lbs./sq. in., gauge	21	35·2	10·2	46·2	8·4
Agitation	290 r.p.m.—16 lbs. of oil	101	31·7	15·8	47·7	4·8
Agitation	408 r.p.m.—12 lbs. of oil	24	32·8	12·4	48·9	5·9
Agitation	528 r.p.m.— 8 lbs. of oil	12	34·2	10·7	47·8	7·3
Amount of catalyst	0·025% Ni.	98	35·1	11·0	45·7	8·2
Amount of catalyst	0·050% Ni.	31	34·1	11·2	47·5	7·2
Amount of catalyst	0·100% Ni.	24	32·8	12·4	48·9	5·9
Nature of catalyst	No. 1—0·050% Ni.	31	34·1	11·2	47·5	7·2
Nature of catalyst	No. 2—0·050% Ni.	35	35·2	19·2	37·2	8·4
Nature of catalyst	No. 3—0·100% Ni.	85	34·1	10·7	48·0	7·2
Nature of catalyst	No. 1—0·025% Ni.	98	35·1	11·0	45·7	8·2
Pressure Rate of agitation Amount of catalyst	10 lbs./sq. in. 290 r.p.m.—16 lbs. of oil 0·300% Ni.	190	31·0	20·4	44·6	4·0
Analysis of cottonseed oil			26·9	—	27·1	46·0

The effects of selective and non-selective hydrogenation on an oil hardened to a given iodine value are briefly as follows:

(*i*) *Selective hydrogenation:* Selectivity keeps the saturated acids percentage constant but decreases the ratio of linoleic to oleic acids. The greater the preponderance of linoleic to oleic transformation, the greater is the possibility of iso-oleic acid formation. It is true that the major amount of isomers is formed by hydrogenation of the 9 : 10 double bond in the linoleic acid, instead of as normally at the 12 : 13 position, to form 12 : 13 iso-oleic acid rather than the normal 9 : 10 oleic acid. The amount of the actual migration of the existing 9 : 10 double bond in the oleic acid present before hydrogenation to the 12 : 13 position is very little. It may be mentioned that temperature is perhaps the most important individual factor controlling the process of hydrogenation. For example, if vegetable oils are being hydrogenated to a melting point of about 37°C, iso-acids are produced so rapidly and to such an extent at very high temperatures that the hardened oils usually do not exhibit all the properties characteristic of selective or non-selective hydrogenation.

(*ii*) *Non-selective hydrogenation:* In normal practice, non-selective hydrogenation gives a greater percentage of saturated fatty acids at a given iodine value than selective hydrogenation. The advantage with non-selective hydrogenation is that fats which are plastic over a fairly wide range of temperatures may be produced, but this is offset by a rather high linoleic acid content which reduces the stability of the resultant product when compared to that of a material hardened to the same iodine value by the process of selective hydrogenation. In other words, whereas non-selective hydrogenation means greater flexibility as far as bakery fats are concerned, it is not to be advocated for the manufacture of products intended to be used solely as cooking media and for which stability is a more important consideration than plasticity.

CHAPTER III

FUNDAMENTALS OF VANASPATI MANUFACTURE*

In manufacturing hydrogenated oils for edible purposes, it is customary to subject the raw oils to the following main processes : pre-refining (alkali refining and bleaching), hydrogenation, post-refining (alkali refining and bleaching) and deodorisation. The following sections deal with the fundamentals of each one of these processes as well as the principles underlying blending and graining.

(a) Alkali Refining

The principal object of alkali refining is to remove the free fatty acids which occur to a greater or lesser extent in all crude vegetable oils and fats as a result of the hydrolytic decomposition of the glycerides under the influence of lipases. The free fatty acid content increases if the seeds or oils are subjected to prolonged storage under adverse conditions. In India, all the oils used for the manufacture of vanaspati are obtained relatively fresh from the seed-crushers, and it is only in rare instances that the free fatty acid content exceeds 3 or 4%. The presence of large amounts of free fatty acids in oils is undesirable from several points of view. For example, the lower fatty acids are characterised by a disagreeable smell and flavour, and the unsaturated fatty acids are more sensitive to oxidation than the corresponding glycerides, thus diminishing the keeping properties of the product. Another objection is the corrosive action exerted by the free fatty acids on various metals, which is normally accompanied by a dark colouration of the oil; furthermore, heavy metal soaps are powerful pro-oxidants. In the case of oils which are intended to be hydrogenated, it is essential that they be as free as possible from fatty acids since free fatty acids interfere with the process of hydrogenation: the free carboxyl groups are selectively adsorbed on the surface of the catalyst where they are rapidly hydrogenated and then remain attached to the surface thereby hindering the hydrogenation of the glycerides.

Before the actual removal of the free fatty acids by the process of alkali treatment, it is sometimes necessary to subject the oils to a process of degumming. The common methods employed for degumming are based on heat treatment, hydration, or treatment with adsorbents, alkali or certain chemicals,

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* In preparing this chapter, the author has drawn freely from the books published by Andersen, Bailey, Schwitzer and Waterman.

such as mineral acids. As the vegetable oils used in India are obtained relatively fresh, the gum or mucilage content is extremely small and, consequently, it is rarely necessary to subject the oils to this pre-treatment prior to alkali neutralisation.

The term "alkali neutralisation" is generally applied to the process of removing the free fatty acids from crude oils and, for many years, the only method used industrially was neutralisation with bases, such as caustic soda and lime. The principal methods of neutralisation or de-acidification which are in vogue at the moment are:

(A) Neutralisation with caustic alkali:

(*a*) Batch process with strong lye,

(*b*) Batch process with weak lye,

(*c*) Batch process with mixed concentrations,

(*d*) Continuous processes,

(B) Neutralisation with alkali carbonate,

(C) Neutralisation with lime and other chemicals,

(D) De-acidification by distillation,

(E) De-acidification by solvent extraction,

(F) De-acidification by esterification.

Of these methods, those under (A) are the most important and widely applied. In recent years, the method (B) has made much progress, particularly in continuous processes. Method (C) is used only in special cases on a limited scale, whereas the methods (D) and (F) are, as a rule, used only in the case of oils and fats with very high free fatty acid contents. The industrial scale application of method (E) is a very recent introduction, and its development is largely dependent on the cost and availability of solvents.

In the vanaspati industry, neutralisation with caustic alkali is done by the batch process, using either strong or weak caustic solutions. In Europe, alkali neutralisation is generally done with weak caustic solution, whereas the strong caustic soda method is almost universal in America. The choice of the concentration of alkali to be used in the neutralisation process depends upon various factors, the important ones being:

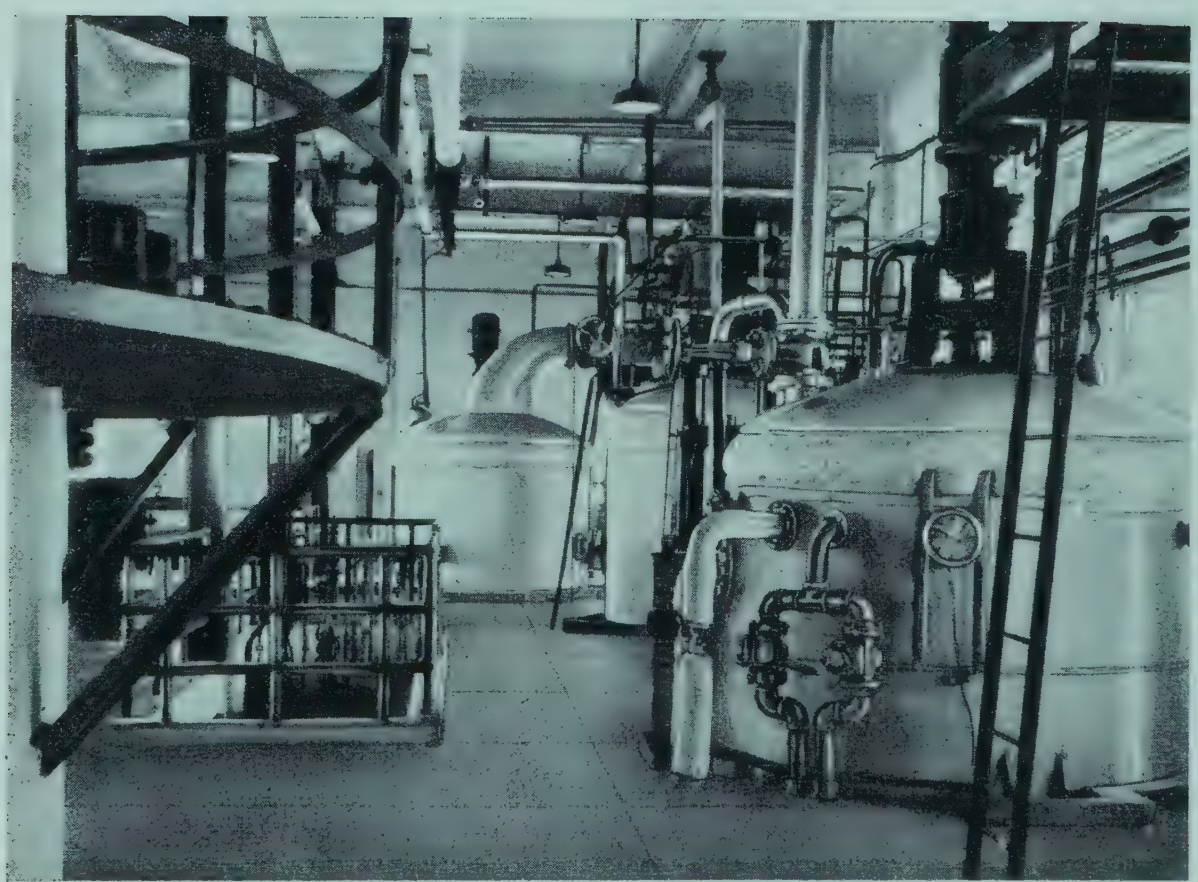


PLATE 2: GENERAL VIEW OF A REFINERY (Left to right: Neutraliser, Deodoriser, Autoclave and Bleacher)

(Courtesy: Messrs. Tata Oil Mills Company Limited, Bombay)

(1) *Nature of soap-stock:* Even at a relatively high water content, a strong solution of caustic soda produces a very viscous soap-stock which sets to a solid mass when cooled. Consequently, the concentration of the solution has to be so chosen that it will allow the soap-stock to flow out of the neutralising vessel at about 60°-70°C. Fats with low iodine values yield a very firm soap-stock, and even liquid oils, such as cottonseed oil, can form a very thick and tough soap-stock when treated with strong caustic solutions. The use of too strong a concentration of caustic solution in excess can lead to the salting out of the soap from the soap-stock.

(2) *Amount of neutral oil saponified:* The higher the concentration of the caustic soda solution, the greater is the danger of some neutral oil being saponified. In other words, the use of a strong caustic alkali can lead to higher refining losses.

(3) *Amount of neutral oil occluded in the soap-stock:* The more dilute the caustic alkali, the greater is the tendency for the soap solution to form emulsions with some of the neutral oil. Generally, fats with lower free fatty acid content can be satisfactorily refined with relatively weak caustic lye, whereas oils with high acid values require stronger caustic. Although the danger of over-saponification is minimised when weak caustic alkali is used, it is offset by the increased loss of neutral oil through emulsification.

(4) *Rate of separation of neutral oil and soap-stock:* The temperature of processing and the concentration of caustic solution should be so chosen that the soap-stock, when it "breaks" in the oil, settles rapidly and compactly at the bottom of the vessel. Slow spongy settling generally results in poor separation or loss of neutral oil by occlusion.

(5) *Colour removal:* The weaker the caustic solution, the greater is the excess of caustic required to obtain, in addition to neutralisation, a good bleaching effect in the oil.

(6) *Acidity of the crude oil:* The strength of the caustic solution should be so chosen that it is related to the free fatty acid content of the oils. The higher the free fatty acid content, the more concentrated should be the caustic. A definite relationship between the acidity of the oil and the concentration of the caustic cannot be laid down, as it varies from oil to oil and depends on a number of factors, such

as the previous history of the oil, the fat-soluble surface active substances contained in it, the content of oxidation products, etc. The concentration of the lye when working with strong caustic varies in practice from 10° to 24° Be. When the dilute caustic alkali method is used, the concentration is generally less than 5° Be.

Several vanaspati manufacturers have installed centrifugal separators with the object of recovering neutral oil from soap-stock. The principle underlying centrifugal separation is well-known and is fairly simple. The liquid passes continuously through a bowl rotating at a high speed, and the centrifugal force separates the liquid oil from the soap-stock. In actual practice, the soap-stock is initially heated by open steam, and salt is added in order to break the emulsion. When the emulsion has broken, the soap-stock is fed to the centrifugal separator, from one spout of which the clear oil is discharged, whereas the de-oiled soap-stock is discharged from another spout specially designed for the purpose. In order to obtain good results, the soap-stock should not be very dilute. If the total fatty matter content is about 50 per cent, the soap-stock is very easy to treat. It is claimed that 50-60 per cent of the neutral oil in the original soap-stock can be recovered by using centrifugal separators. The same plant can be used for the de-oiling of the emulsions and wash waters.

Neutralisation with caustic soda is carried out in open or closed vessels or kettles, the cylindrical part of which is approximately 2 to $2\frac{1}{2}$ times the diameter. The angle at the apex of the cone should be about 90° in order to facilitate draining. Some vessels are provided with steam jackets around the lower half of the vessels and the cone, but, to obtain more rapid control of temperature changes, most vessels are fitted with internal coils for steam heating, or with jackets as well as coils. Various types of heating coils are used, such as helical coils or vertical coils connecting circular headers. A perforated steam distributing coil at the bottom is provided if a supply of direct steam is required.

The vessels are provided with stirrers, the types varying according to the manufacturer's ideas of construction, but the essential point is that they should give effective mixing without excessive emulsification or centrifugal effect. The stirrers are either of the gate type, grid type, paddle type, propellers or helical screws. They are usually arranged with variable speed since slow stirring is required on certain occasions.

The neutraliser is provided at the top with a device, in the form of a circular perforated pipe or spray nozzles, for the efficient, quick and uniform

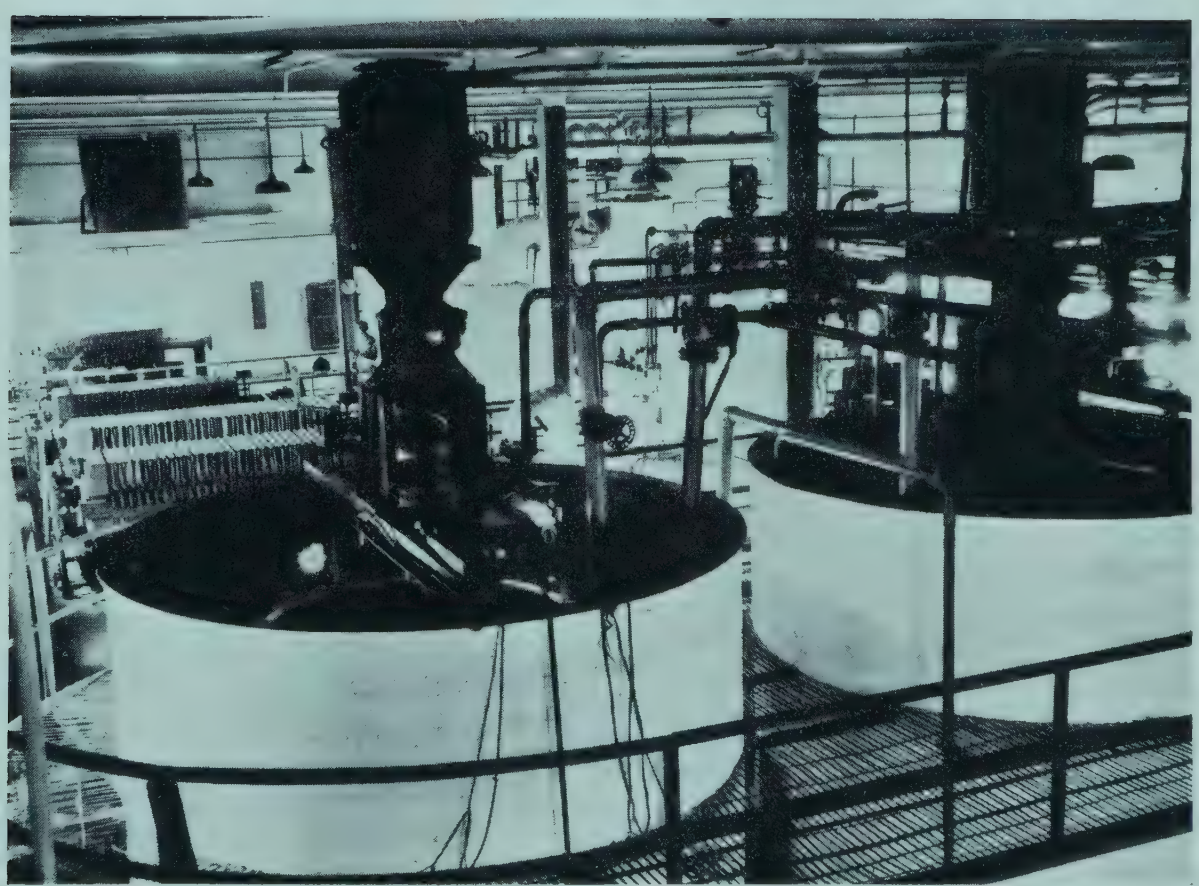


PLATE 3: NEUTRALISERS

(Courtesy : Messrs. Tata Oil Mills Company Limited, Bombay).

distribution of the lye, water and other liquids over the surface of the oil. The vessels are usually provided with one or two sampling cocks at some distance from the bottom outlet in order to obtain indication of the separation of the layers during settling and draining.

(b) Bleaching

The object of bleaching or decolorising is to remove the colour constituents of the oil. A certain reduction in the colour of the oil occurs during the process of alkali neutralisation, and further decolorisation also occurs during hydrogenation and deodorisation. In the bleaching process, the removal of the colouring matters is the main objective.

The natural colouring matters are principally carotene, xanthophyll and chlorophyll. Other less well-defined colouring matters may also be present. They are all derived from the oil-bearing materials and impart to the crude oils their characteristic yellow, orange and greenish shades. Certain other colouring matters which are found in crude oils, and which are difficult to bleach, are believed to be the degradation products of natural colours, or the result of the faulty storage and processing of the oilseeds, oxidation of the oils, oxidation of the unsaponifiable matter, etc.

For bleaching vegetable oils, the neutralised oil is subjected to a physical method in which the colouring matter is adsorbed on the surface of bleaching earths or bleaching carbons. Certain colouring matters, such as carotenoids and various quinonoid derivatives can be almost completely removed from the oils by this method. There are, however, other colouring principles which resist this treatment and a residual colour persists even after bleaching.

The adsorbents used for bleaching oils and fats are mainly natural and acid-activated clays, and to a lesser extent activated carbon. They possess the power to adsorb on the surface not only the colouring materials but also oil and other substances which are suspended in oil in a colloidal form, namely, traces of soap, gums, resins and certain degradation products. In addition, depending upon the nature of the oil, certain physico-chemical changes can occur, such as the displacement of the double bonds.

The amount and type of bleaching earth or carbon required to decolorise an oil depends upon the nature and colour of the oil and the extent of decolorisation desired. The usual amount of bleaching earth used is 1 to $2\frac{1}{2}$ per cent by weight on oil. In actual practice, the desired amount of adsorbent is drawn into the vacuum bleaching vessel and mixed with the pre-dried oil, and the temperature is increased as rapidly as possible to that desired for

bleaching and maintained there for the duration of the bleaching process. The average time is usually about 30 minutes, and the temperature varies between 70° to 100°C. With certain oils, it may be necessary to prolong the bleaching period and increase the temperature above 100°C. In the case of *sesame* oil which is used in vanaspati as a latent colouring agent, it is essential that the sesamol content is not affected, and hence the oil is bleached with a neutral or slightly alkaline bleaching earth at as low a temperature as possible.

After bleaching, the contents of the vessel are cooled to a temperature low enough to avoid oxidation of the oil but still high enough to allow it to flow easily through the filter-press. The vacuum is then broken and, while the agitators are kept moving sufficiently fast to keep the adsorbent evenly suspended without beating in air, the mixture is filtered through frame presses either by air pressure from the bleaching vessel or by pump pressure. In the latter case, the pumps should give a steady flow without pulsations; the smoothest filtration is achieved by air pressure. It is often useful to cover the filter cloths with a layer of filter paper to obtain a clearer filtrate as well as to lessen wear on cloths. The press cake is easily removed when filtration is complete, and the cloths can generally be reused for several filtrations before changing them for cleaning. The dimensions of the presses should be calculated to permit filtration to be completed in 1 or $1\frac{1}{2}$ hours. If the proportion of the adsorbent and oil retained in the press cake would necessitate a longer time, it is advisable to filter through two presses in parallel.

Activated carbons are usually better decolorising agents than bleaching earths. Furthermore, they do not impart to the oils the typical earthy flavour or taste, and from these two points of view, activated carbon may be considered to be more efficacious in use than bleaching earths. On the other hand, it is believed that the chemical changes (displacements of the double bonds) which occur in the case of activated carbons are far greater than those obtained when bleaching earths are employed. This is a significant point to be considered inasmuch as the shifting of double bonds can sometimes lead to misleading conclusions: the colour of the freshly bleached oil may be light but, on storage, the double bonds can revert to their original positions thus leading to a recession in the colour and a possible reversion of flavour and taste.

There is one further disadvantage in the use of activated carbons inasmuch as the filter cakes retain more oil than when bleaching earths are used. This is illustrated by the figures presented in Table 9.

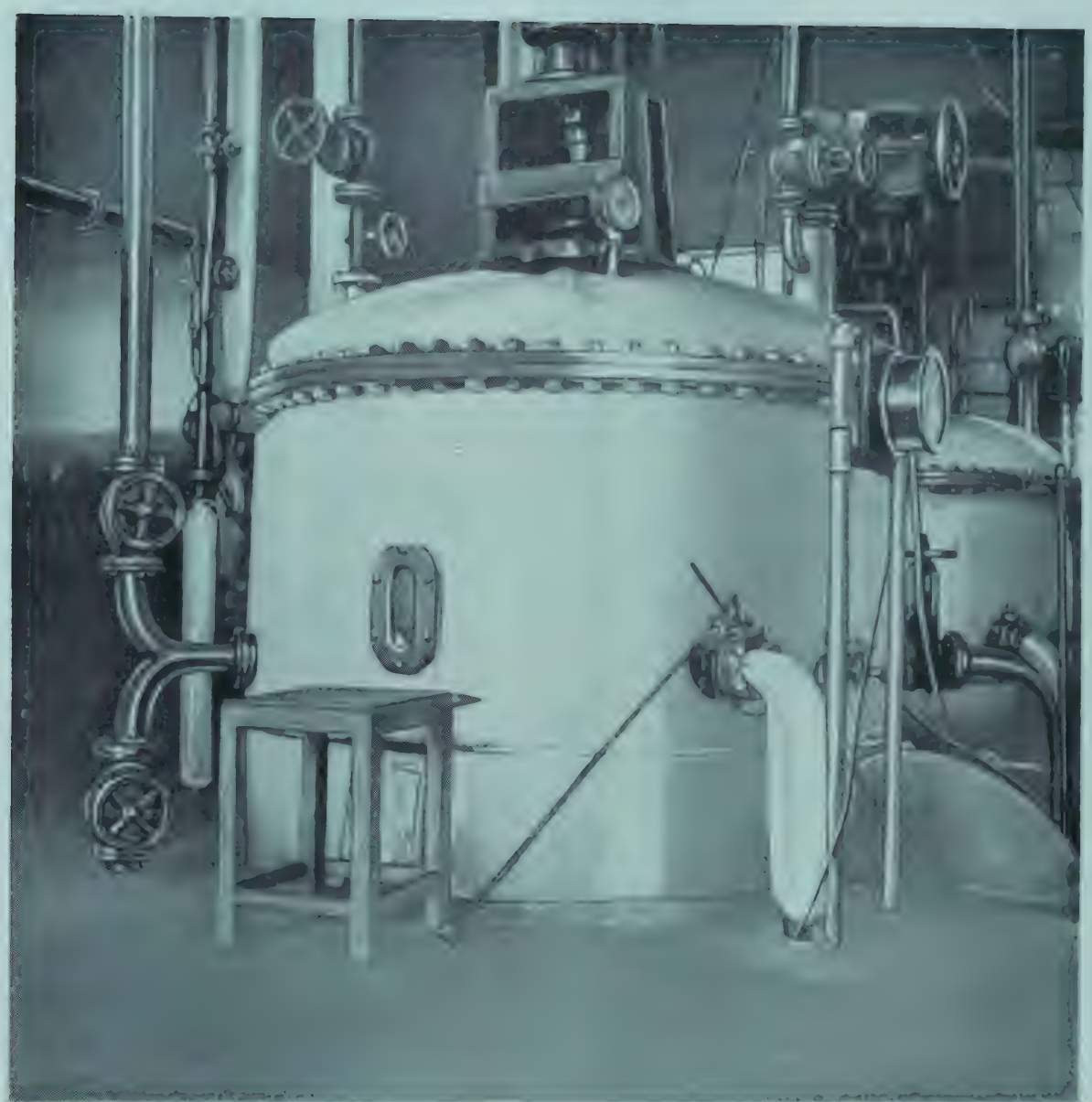


PLATE 4: VACUUM BLEACHER
(Courtesy : Messrs. Kusum Products Limited, Calcutta).

PLATE 5: FILTER PRESS

(Courtesy: Messrs. Indian Vegetable Products Limited, Bombay)

Table 9: Oil Retained by Different Adsorbents

Adsorbent	Oil in filter cake (Weight per cent)
Untreated bleaching earths	25—30
Activated bleaching earths..	30—50
Activated carbons	50—70

By using mixtures of bleaching earths and activated carbons, it is possible to combine the advantages of both the products in order to obtain a given decolorising effect as economically as possible. The cost of the adsorption medium is the most important factor in this process, and the bleaching effect of the mixture should be greater than the calculated additional value.

The evaluation and selection of adsorbents have always been a problem with oil refiners. In actual plant operation, it is not possible to follow strictly the equations for adsorption isotherms as propounded by Langmuir, van Bemmelen or Freundlich. In any case, they yield data only regarding the decolorising properties of the adsorbents under the particular conditions of the test. In selecting adsorbents, it is necessary to consider various other points, such as, oil retention, rate of filtering, effect on quality, etc. No standardising body has so far published any specifications or methods of test on the subject of bleaching earths and activated carbons used in the vegetable oil industry. The Indian Standards Institution have undertaken this task, and tentative methods for sampling and test for activated carbons as well as bleaching earths are currently in the process of being prepared. The efforts made by the Indian Standards Institution are laudable and it is hoped that the vegetable oil refining industry in this country will derive the fullest benefit when the methods are published.

Oils are bleached in enclosed vessels which are nearly always constructed for working under low or high vacuum. The oil is heated by closed steam coils and can, if desired, be dried under vacuum before bleaching. The adsorbent is drawn in by vacuum through a pipe at the top. This is usually sufficiently long to discharge the adsorbent under the surface of the oil. The stirrers revolve sufficiently rapidly and are so constructed that they prevent any settling of the adsorbent at the bottom of the vessel. The vessels are sometimes provided with a pipe line for compressed air in order to enable filtration to be conducted under air-pressure.

Bleachers may be either vertical or horizontal in shape. The horizontal bleachers are preferred by certain manufacturers although they have now become almost obsolete. The horizontal vessels are heated by steam jackets which cover the lower half. They require less power for stirring which is generally done by a spiral paddle arrangement. A dome at the top of the vessel connects it to the vacuum system, and the adsorbent is drawn in at one end through a pipe from the top which dips well into the oil.

Irrespective of the design or shape of the bleacher, it is absolutely essential that the vessel is air-tight, particularly below the oil level, because air leaking into the hot oil, especially in the presence of the adsorbent, can cause oxidative deterioration of the oil. A bleacher, therefore, has to be tested at frequent intervals for air-tightness. Particular attention should also be given to the tight closing of the bottom outlet valve where particles of bleaching earth may be lodged when the vessel is being emptied.

(c) Preparation of Catalyst and Hydrogen

(i) Catalyst

The most important catalysts which have found application in the hydrogenation of vegetable oils are nickel-kieselguhr catalyst, nickel from nickel formate, and Raney nickel.

Nickel-kieselguhr catalyst is usually prepared by adding a solution of soda ash to a solution of nickel sulphate, boiling the mixture for some time, and then adding a quantity of kieselguhr to it. After continued boiling, the mass is filtered hot and washed carefully. After drying and grinding, the material is reduced in an atmosphere of hydrogen at about 420°-500° C. After reduction, the catalyst is suspended directly in an appropriate oil in order to prevent oxidation of the metal which is frequently pyrophoric. Good commercial catalyst can be prepared by this method.

When a mixture of nickel formate and oil is heated, the salt begins to decompose at about 150° C with the evolution of a large amount of gas :

$$Ni(CHO_2)_2.2H_20 \rightarrow Ni + 2C0_2 + H_2 + 2H_20$$

The nickel is produced in a very finely divided state and is dispersed in the oil. By raising the temperature carefully to about 240°C, the decomposition takes place quantitatively, the oil being hydrogenated to some extent by the hydrogen which is evolved. In actual practice, the catalyst is prepared in a simple cylindrical reactor which is directly heated, usually with electric heater, and fitted with a cooling coil to prevent the reaction from becoming too

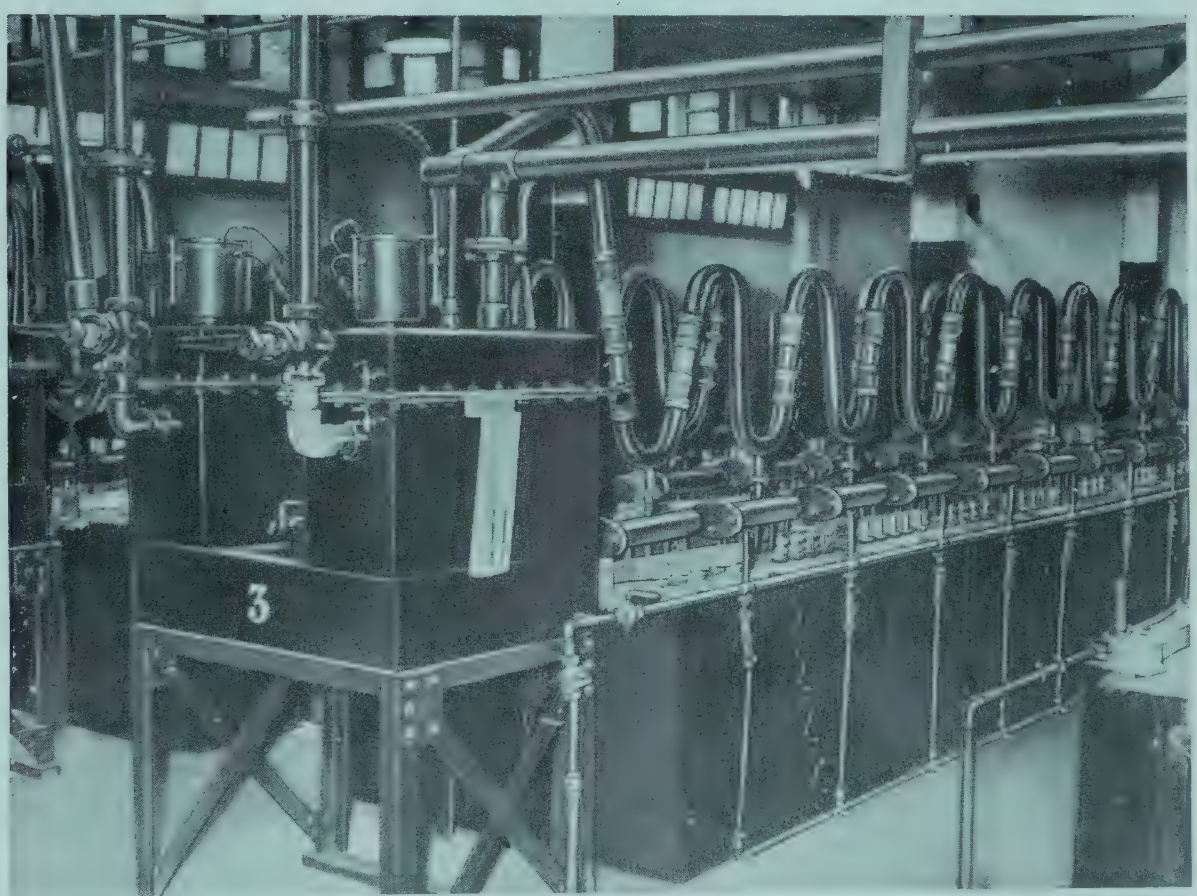


PLATE 6: CELL ROOM—MANUFACTURE OF HYDROGEN BY ELECTROLYTIC METHOD
(Courtesy: Messrs. Indian Vegetable Products Limited, Bombay)

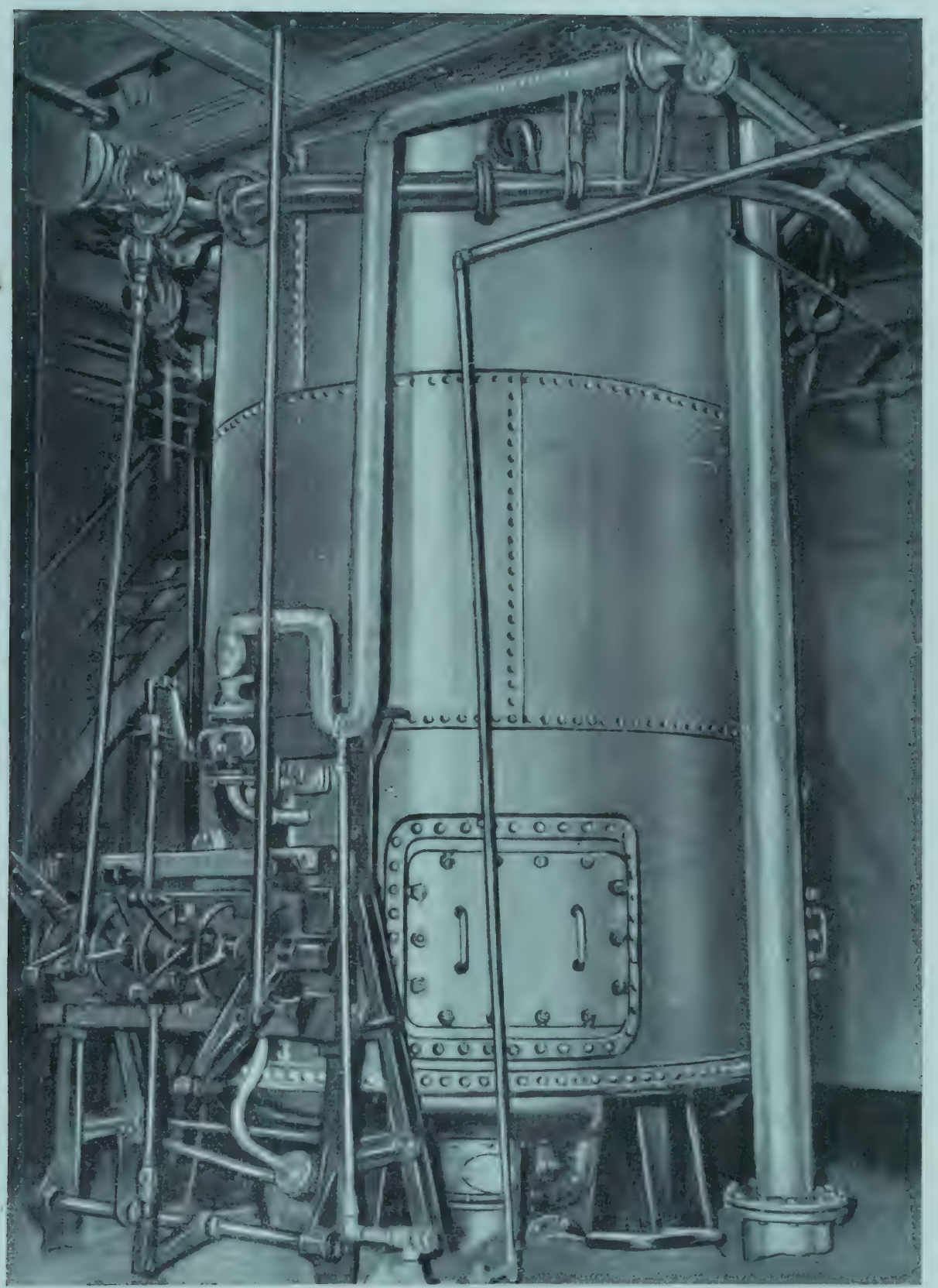


PLATE 7: GAS GENERATOR—MANUFACTURE OF HYDROGEN BY STEAM-IRON PROCESS

(Courtesy: Messrs. Swastik Oil Mills Limited, Bombay)

vigorous. Usually, 4 parts of oil and 1 part of nickel formate are used and a product is obtained containing about 7 per cent nickel; if a more concentrated catalyst mixture is desired, nickel formate may be added in any quantity upto about the weight of the oil. The advantage of this catalyst lies in the relatively simple method of preparation. Its catalytic properties are very good. A disadvantage, however, is that it is sometimes difficult to remove completely the finely divided metal from the hydrogenated oil by filtration, and hence an after-treatment is necessary. This catalyst is used by most of the vanaspati manufacturers in India.

Raney nickel catalyst is prepared by treating a nickel-aluminium alloy (50 per cent nickel) in powder form with a concentrated solution of caustic soda whereby the aluminium dissolves as aluminate, and the nickel remains behind as an active catalyst. The simplicity of the method of preparation has stimulated the use of this catalyst, but it is not employed to any large extent in the vanaspati industry.

(ii) *Hydrogen*

There are several methods of preparing hydrogen which depend principally on the local environments and available raw materials. The methods used in India by the vanaspati manufacturers are the electrolytic and steam-iron methods.

In the steam-iron method, iron oxide is reduced by water-gas or producer gas to iron which, with steam, readily gives hydrogen with the reformation of the oxide :

$$C + H_2O \rightarrow CO + H_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$Fe_3O_4 + 4(CO + H_2) \rightarrow 3Fe + 4CO_2 + 4H_2 \quad \ldots (2)$$

$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The hydrogen is cooled and scrubbed with caustic soda solution to remove carbon dioxide. This gas still contains small quantities of carbon monoxide and is therefore purified further by catalytic conversion. The steam-iron process is cheap to operate where electricity is comparatively expensive. On the other hand, capital costs are high for small hydrogenation plants and hence it is not widely used in the vanaspati industry in this country.

In the electrolytic method, an electrolyte, such as 23° Be sodium hydroxide or 31° Be potassium hydroxide, is charged into a cell and an electric current passed through the solution. The electric current causes the decomposition

of the water into hydrogen and oxygen. The gases are collected over their respective electrodes and piped to a low pressure storage tank. Two types of plants for the electrolytic production of hydrogen are in use in India, namely, a battery of simple cells of the well-known Knowles' type and connected in series, and the bipolar cells of the "filterpress" model. Most of the vanaspati factories in India using the "filterpress" type are equipped with Bamag plant, while in the case of those using the other type, some are equipped with cells of Indian manufacture.

All commercially produced hydrogen contains impurities. These impurities may be divided into four groups in accordance with their behaviour in hydrogenation:

(1) Gases which have no effect on the catalyst or the oil. Their effect is merely to dilute the hydrogen. Typical example: nitrogen.

(2) Gases which, under the influence of the catalyst, undergo chemical reactions and thereby use some of the catalyst for such other reactions. Typical example: carbon monoxide.

(3) Gases which react chemically with the catalyst and inactivate it. Typical example: hydrogen sulphide.

(4) Gases or vapour which can react chemically with the oil. Typical example: steam.

The hydrogen made by the electrolytic process is very pure, containing only oxygen as an impurity. Typical analyses of hydrogen gas manufactured by the electrolytic and steam-iron processes are given in Table 10.

Table 10: Analysis of Hydrogen Gas

		Electrolytic	Steam-iron
Hydrogen	(%)	99·95	99·1
Nitrogen	(%)	Nil	0·5
Oxygen	(%)	0·05	0·1
Carbon dioxide	(%)	Nil	0·1
Carbon monoxide	(%)	Nil	0·2

(d) Hydrogenation

The theoretical principles underlying the process of hydrogenation have been discussed in the preceding chapter.

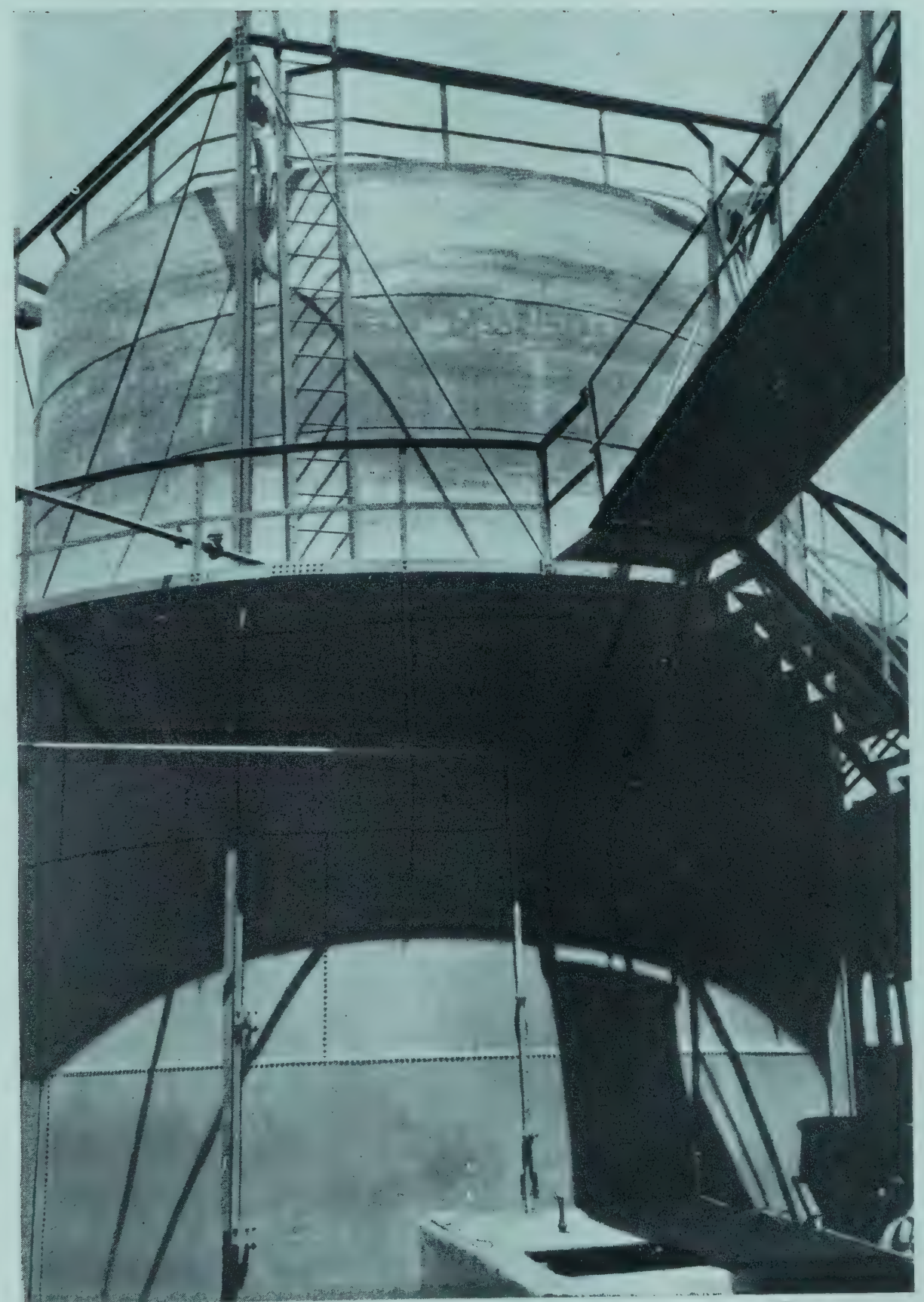


PLATE 8: HYDROGEN HOLDER

(Courtesy: Messrs. Swastik Oil Mills Limited, Bombay)

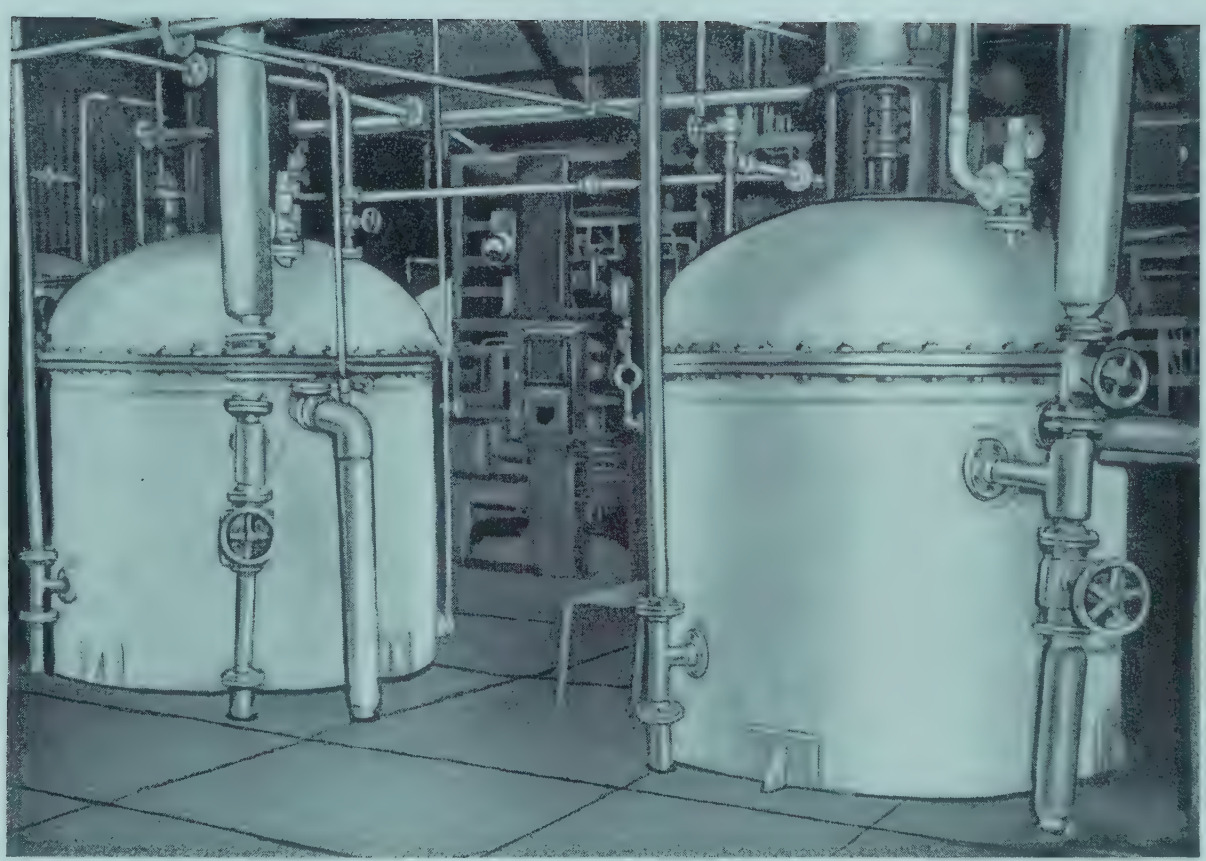


PLATE 9: AUTOCLAVES OR HYDROGENATING VESSELS
(Courtesy: Messrs. Swastik Oil Mills Limited, Bombay)

Plants for the hydrogenation of oils have been developed mainly along two lines. In one type of hydrogenator, the hydrogen is injected at the bottom of the vertical vessel and the excess hydrogen is withdrawn at the top by means of a circulating compressor. This compressor blows the excess hydrogen through a train of scrubbing towers in which the gas is dried, deodorised and freed from entrained oil droplets before returning it to a gasholder from where it is recirculated. In this system, agitation of the oil is aided by a stirrer. In the other type of convertor, hydrogen is introduced in a similar way but it is not circulated. Instead, the oil containing the catalyst is withdrawn at the bottom and circulated back into the top of the convertor. The disadvantage with this method is that moisture and inert gases accumulate in the convertor, particularly if electrolytic hydrogen is not used. This can retard the hydrogenation reaction which will affect output. Alternatively, the gas has to be purged or vented more often, but this leads to increased hydrogen losses.

In some modern plants, a combination of both these systems is employed: the hydrogen and oil are pumped round, and a stirrer is also used. By this means, it is possible to get as intimate a contact as possible between the gas, oil and catalyst to ensure a rapid reaction. [137]

In actual practice, the hydrogenator is charged with pre-refined oil and catalyst, and the system is heated by steam in coils. Hydrogen is introduced into the vessel and the heating is increased to about 160° - 180°C. Once the reaction has started, heating is hardly necessary due to the exothermic nature of the process. In fact the charge may have to be cooled in order to control the temperature. Groundnut and cottonseed oils are relatively easily hydrogenated, and it is hardly ever necessary to increase the temperature beyond 180°C. After the oil charge has been hydrogenated to the desired melting point, it is cooled carefully and then filtered to remove the catalyst.

(e) Refining of Hydrogenated Oils

During the process of hydrogenation, which is carried out at high temperatures, the percentage of free fatty acids increases slightly, and the product sometimes acquires a "hardening flavour" or "hardening taste" which is believed to be caused by certain aldehydes. [127] Also, however efficient the filtration may be, the hydrogenated oil contains small varying quantities of nickel. In order to improve the quality of the product, it is preferable to neutralise and bleach it prior to subjecting it to the deodorisation process.

The processes and plant employed for the alkali neutralisation and bleaching of the hydrogenated oil are fundamentally the same as those described

in sections (*a*) and (*b*) of this chapter. The conditions are however less rigorous: neutralisation is done with dilute caustic alkali, and bleaching is effected with about $\frac{1}{4}$ or $\frac{1}{2}$ per cent of earth. The former treatment reduces the free fatty acid content of the oil, removes some of the malodorous constituents and renders the nickel in a form such that it is easily adsorbed on the bleaching earth in the subsequent bleaching process.

(f) Deodorisation

Although alkali refining and bleaching generally remove some flavouring substances, many of these are tenaciously held in the oils and can be eliminated only by the process of deodorisation. The flavouring substances may be considered as belonging to the following two groups:

(1) substances which are responsible for the characteristic odour and taste of the oils, and are present in the fresh oils from undamaged seeds;

(2) substances which arise from the deterioration of the oils or seeds during storage, transport and processing, and impurities admixed adventitiously during these stages.

Deodorisation is the removal of the odoriferous matter by distillation in a current of steam in vacuum and at elevated temperatures (150° - 250°C). Under these conditions, neutral fat is not volatile. The vapour pressure of the odoriferous compounds is so low that very high temperatures would be required to distil them off at atmospheric pressure; hence the need for a good vacuum and a current of inert gas to reduce the distillation temperature below that at which damage or decomposition of the neutral oil might take place. Of the inert gases, dry steam is the most suitable: it is cheap, has a high specific volume, and can be condensed and removed fairly easily from the system. Deodorisation is thus essentially a distillation in a current of steam. It also removes small quantities of free fatty acids and colouring matter.

A deodoriser is a cylindrical vessel with a shallow-dished top and bottom. The height is usually about twice the diameter, and the working capacity is slightly more than half the volume thus providing ample headspace for expansion of the charge when heated up, and for ebullition and splashing. An amply dimensioned vapour-offtake at the top connects the vessel with the vacuum system through an oil-catcher to collect entrained particles. The vessel is fitted with an internal heating coil and when the temperature of the oil has reached 80°- 90°C, open superheated steam is blown in through an inlet at the bottom. For satisfactory and rapid deodorisation, a vacuum

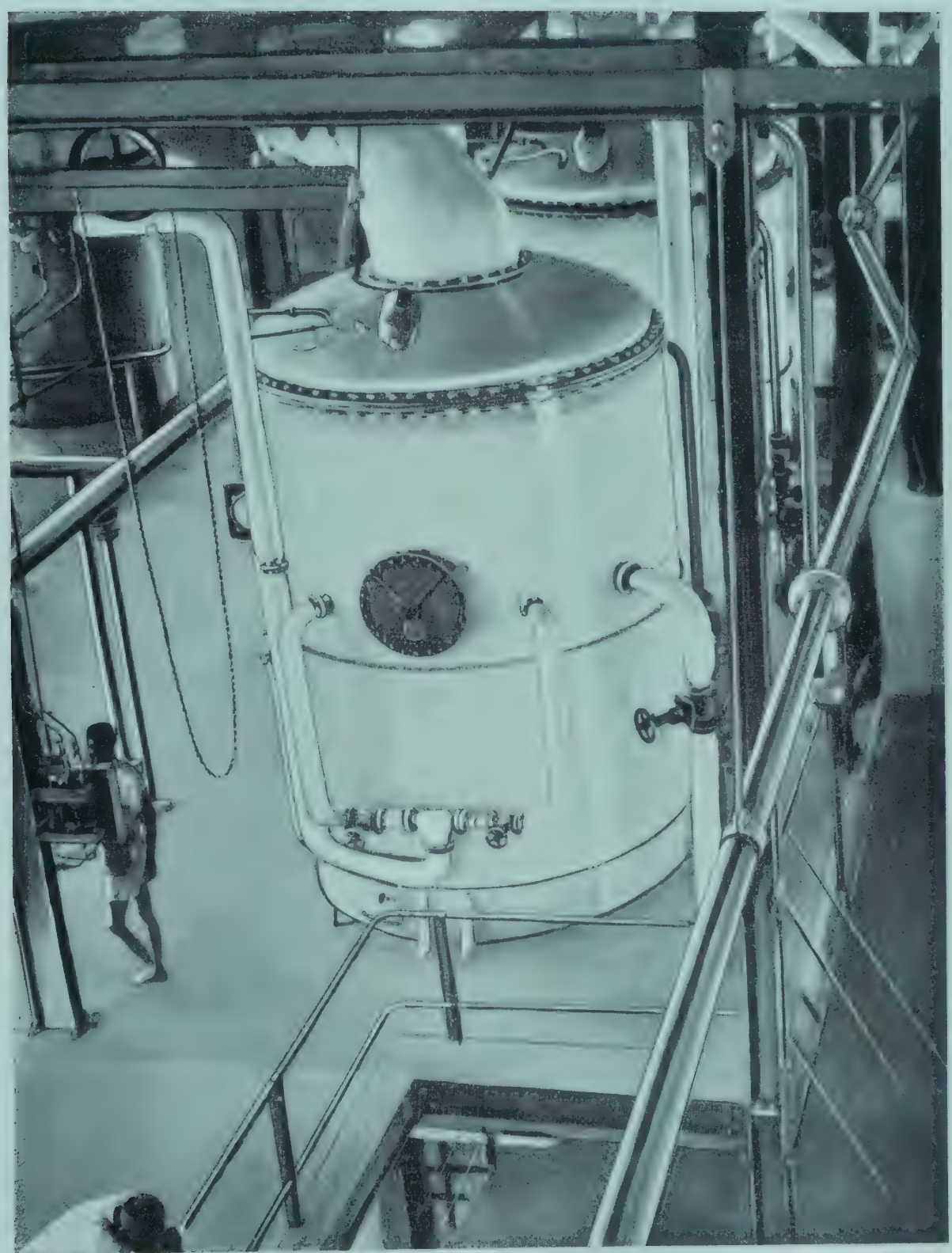


PLATE 10: DEODORISER

(Courtesy: Messrs. Kusum Products Limited, Calcutta)

of at least 29″ should be employed since the volatility of the products to be removed is directly dependent on this factor. If the vacuum is not sufficiently high, the steaming temperature has to be raised in order to distil off the odoriferous substances, and such temperatures should be avoided. During the deodorisation process, which may last for several hours, the temperature of the oil should be maintained at about 160° to 180°C. With higher temperatures, deodorisation can be completed in a much shorter time, but a very high vacuum must be maintained to prevent oxidation or decomposition of the oil. After deodorisation, the oil is cooled under vacuum to about 80°C after which it is dropped into a storage tank. Sometimes, the deodorised oil is filtered before storage.

(g) Finishing Processes

Vanaspati is a hydrogenated vegetable oil product intended for edible purposes. A large proportion of the vanaspati manufactured in India is consumed as a relatively inexpensive alternative to ghee, and it is natural therefore that such a product should as closely simulate the latter as possible. Government legislation does not permit the incorporation in vanaspati of any colours or flavours resembling ghee and, consequently, the only obvious resemblance between the two products is in their granular texture. Although this type of vanaspati represents the bulk of the product manufactured in India, there is nevertheless a certain small proportion which is specifically manufactured to a non-granular texture. Such products are used principally for confectionery and bakery purposes.

The texture of vanaspati is determined largely by physico-chemical considerations, the more rapid the cooling conditions, the smaller is the grain size. In the case of vanaspati manufactured to a granular texture, the product is filled into tins while it is in a liquid condition (50° - 60°C), and the sealed tins are subjected to a process of slow cooling. In the case of non-granulated products, the vanaspati is chilled rapidly and then filled into the tins while it is still in a semi-solid but nevertheless pourable or pumpable condition. The tins are not subjected to any further cooling process. The salient features of the finishing processes employed in the manufacture of vanaspati are described below:

(*i*) *Blending*: *Sesame* oil and hydrogenated groundnut (or cottonseed) oil are usually stored in separate tanks after they have been deodorised individually. Appropriate quantities of the two oils are pumped into a blending tank and mixed intimately for a few minutes. Small portions of the blend are examined for melting point and Baudouin

colour reading and, if the results of these tests conform to the prescribed specifications, appropriate quantities of vitamin A (and vitamin D) are added to the blending tank. The vanaspati is in a liquid condition at this stage, the temperature being about 50° - 60°C.

(*ii*) *Slow cooling*: Vanaspati is a mixture of various triglycerides. According to Bailey[4], sub-microscopic nuclei of solid triglycerides are formed in fats even at temperatures well above the dilatometric melting point. In a product like vanaspati, it is believed that, with a slow rate of cooling, these crystals of solid triglycerides grow by the deposition of mixed triglycerides around the nuclei. As the temperature falls, the solution of iso-oleic triglycerides in the liquid phase of vanaspati becomes supersaturated and there arises a point at which nucleation by iso-oleic glycerides commences, giving rise to the evolution of considerable heat of crystallisation. The rate of fall of temperature of the mass decreases at this point and, with insufficient external cooling, the temperature of vanaspati can rise and even increase sufficiently to cause the re-melting of the outer layers of the grown crystals. This should be avoided because no matter how rapidly the product is cooled after the iso-oleic nucleation period, the product will be non-homogeneous in its consistency and texture. It is believed that the granular texture of vanaspati is due in the main to the large saturated glyceride crystals and that its firmness results from the very large number of iso-oleic nuclei.

In actual practice, the slow cooling of vanaspati with the object of obtaining a granular texture is conducted as follows. As filled into tins, vanaspati is moderately hot and it is customary to allow the tins to stand for a certain interval of time during which period the heat content of the product is partially dissipated by the process of radiation. When the temperature of the product approaches that of the ambient air, the rate of cooling becomes very slow and uneconomic. At this stage, fresh air is blown for short periods of time. When the product shows signs of incipient crystallisation, refrigerated air is blown. By resorting to rapid cooling at this stage, the time cycle is reduced and the product achieves a homogeneous and fairly firm consistency.

(*iii*) *Rapid cooling:* The two methods which are employed in India for the manufacture of non-granulated vanaspati are cooling on chill rolls and continuous cooling inside tubes. The plant used in the

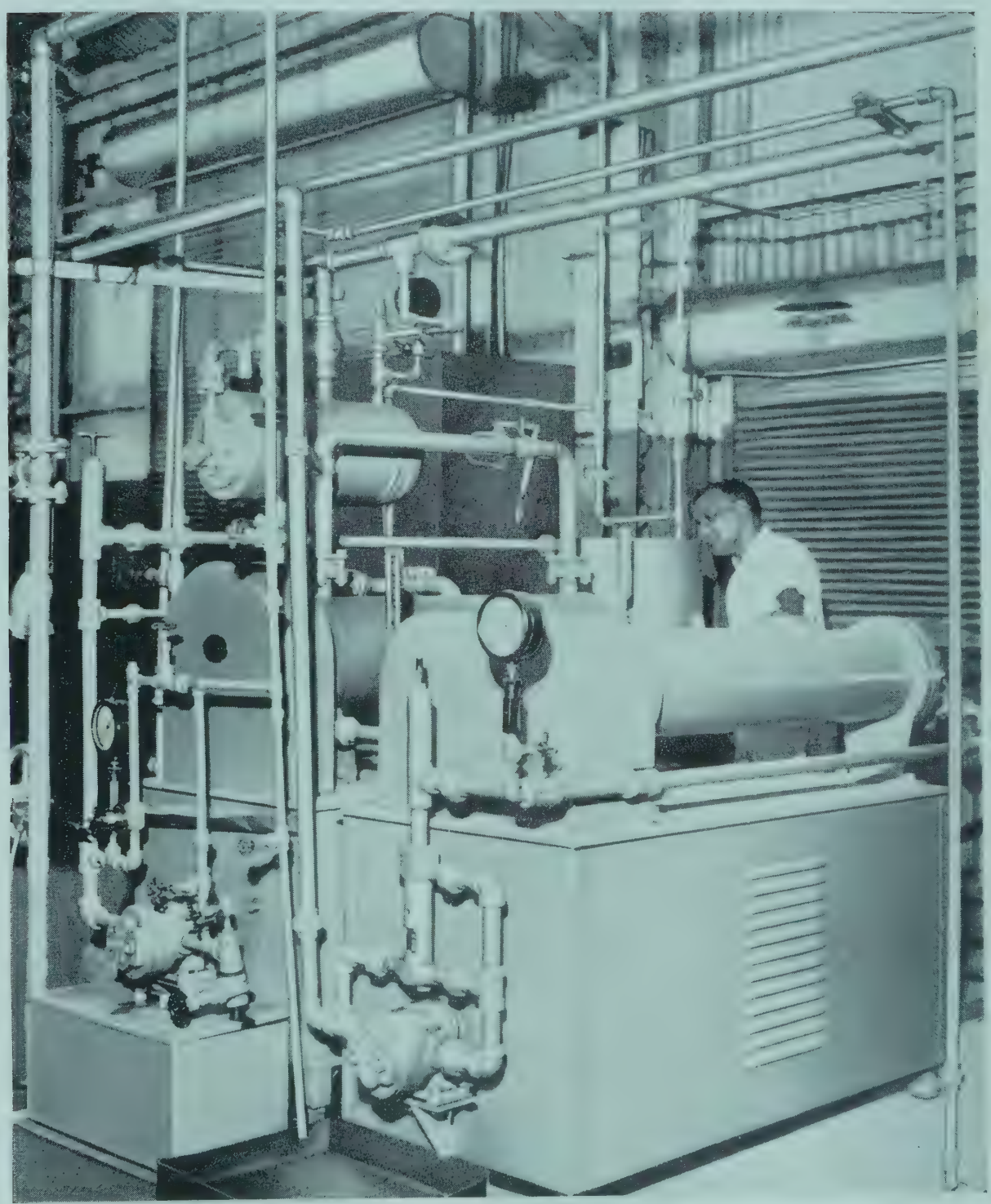


PLATE 11: VOTATOR

(Courtesy: Messrs. Tata Oil Mills Company Limited, Bombay)

former method is very simple and consists of a chilling roll (large hollow cylinder with a machined and ground surface) which is mounted so as to rotate on its longitudinal or horizontal axis at a speed of about 10 revolutions per minute. It is refrigerated internally by the direct expansion of ammonia or by the circulation of cold brine. The molten fat is fed to the chilling roll in the form of a thin film from a trough bearing against the surface of the roll and the solidified fat is scraped off by a blade bearing against the roll near the bottom of the feed trough. The solidified fat drops into a "picker box" which consists of an open trough with a screw conveyor provided with blades which beat air into the fat, the amount of air incorporated being controlled by varying the level of the fat maintained in the picker box. The fat which is in a semi-solid state is then pumped to the filling machine.

The alternative method of producing non-granular vanaspati, namely chilling inside tubes, is fast supplanting the chill roll. A continuously working machine, in which a short horizontal chilled tube is the essential part, is manufactured in England by Messrs. William Douglas and Sons, Ltd. The best known continuous machine is the Votator, and Messrs. Tata Oil Mills Co. Ltd. are pioneers in the use of this plant for the manufacture of non-granulated vanaspati.

In the Votator process, the blended vanaspati is piped from storage to a small float-controlled tank on the Votator machine from which it is forced under a pressure of about 300 p.s.i. to a pre-cooler where the temperature is reduced to 115° - 120°F. Air, or preferably an inert gas like nitrogen, is drawn into the hot oil at the inlet of the pump, the amount of air or nitrogen to be incorporated being regulated by means of a valve. The fat is then pumped into the processing tube or series of tubes designed as 'A' unit, where it is chilled to 60° - 65°F. The processing tube consists of an externally-refrigerated cylinder equipped with fast-revolving scraper blades which bear lightly against the cylinder walls by centrifugal force and by the resistance to rotation offered by the fat. The fat leaves the 'A' unit in a supercooled and highly fluid condition but with the nuclei established for the formation of exceedingly minute crystals. It then passes to the 'B' unit which comprises a closed cylinder or cylinders somewhat larger than the chilling cylinder and equipped with revolving shafts with spirally located

fingers that intermesh with stationary pins in the cylinders. The cylinders of the 'B' unit are not jacketed or cooled and merely serve to maintain the fat in a state of uniform agitation. Owing to the liberation of its heat of crystallisation, the temperature of the fat in the 'B' unit rises to 75° - 85° F., but after leaving this unit there is no appreciable change in its temperature or physical characteristics. An extrusion or atomising valve is placed in the pipe line between the 'B' unit and the filling machine to give the fat added smoothness and a satin-like finish.

(h) Plant Requirements

Plant capacities are determined on the basis of production targets which are set by marketing requirements which, in their turn, are influenced by various policy considerations. However, actual items of plant do not vary a great deal, and the essential requirements for a vanaspati factory with an output of 25 tons per day are as follows:

I. *Oil receiving and storage*

1. 2 × 200 tons capacity storage tanks for raw groundnut oil.
2. 2 × 50 tons capacity storage tanks for raw *sesame* and cotton-seed oils.
3. 1 weigh tank.
4. 1 weigh scale.
5. 2 underground tanks.
6. 2 pumps.

II. *Pre-refining*

1. 1 Neutraliser, 10 tons capacity.
2. 1 Vacuum-bleacher, 5 tons capacity.
3. Caustic soda dissolving tank.
4. Storage tanks for caustic and hot water.
5. Tanks for soap-stock and emulsion.
6. Centrifuge.
7. Filter-press.
8. 2 storage tanks for neutralised oil.
9. 2 storage tanks for bleached oil.
10. Pumps.

III. *Hardening*

1. 1 Autoclave or hydrogenator, 7½ tons capacity.
2. Catalyst reducer.

3. Catalyst feed tank.
4. Vent tank.
5. Oil and catalyst pump.
6. Catalyst mixer.
7. Filter-press.
8. 2 cloudy oil tanks.
9. 2 storage tanks for hardened oil.
10. Pumps.

IV. *Post-refining*

1. 1 Neutraliser, 10 tons capacity.
2. 1 Vacuum-bleacher, 5 tons capacity.
3. Storage tank for caustic.
4. Tank for emulsion.
5. Filter-press.
6. 2 Storage tanks for post-neutralised oil.
7. 2 Storage tanks for post-bleached oil.
8. Pumps.

V. *Deodorising*

1. 1 Deodoriser, 10 tons capacity.
2. Vacuum pump and steam ejector.
3. 1 Vacuum cooler for deodorised oil.
4. 2 Storage tanks for deodorised hardened oil.
5. 1 Storage tank for deodorised *sesame* oil.
6. Pumps.

VI. *Packing and finishing*

1. 2 Blending and tempering tanks.
2. Filling and seaming units.
3. Cooling rooms with refrigeration unit, or Chilling roll or Votator.
4. Warehouse.

VII. *Acid oil* (*Soap-stock treatment*)

1. 4 wooden vats.
2. Storage tank for concentrated sulphuric acid.
3. Storage tank for dilute sulphuric acid.
4. Pumps.

VIII. *Hydrogen production*

Electrolytic process:

1. Electrolytic cells.
2. Source of direct current (Motor-generator set or rectifier).
3. Water distillation still.
4. Low pressure hydrogen storage tank.
5. Hydrogen compressor.
6. High pressure hydrogen storage tank (s).

Steam-iron process:

1. Water gas or producer gas generator.
2. Water gas or producer gas holder.
3. Centrifugal blower.
4. Hydrogen generator.
5. Hydrogen purification equipment.
6. Low pressure hydrogen holder.
7. Hydrogen compressor.
8. High pressure hydrogen cylinders.

IX. *General services*

1. Boiler plant.
2. Vacuum equipment for bleachers, autoclave and deodoriser.
3. Air compressor.

Note :—The sizes for the different units given above may vary with different makes of the plant.

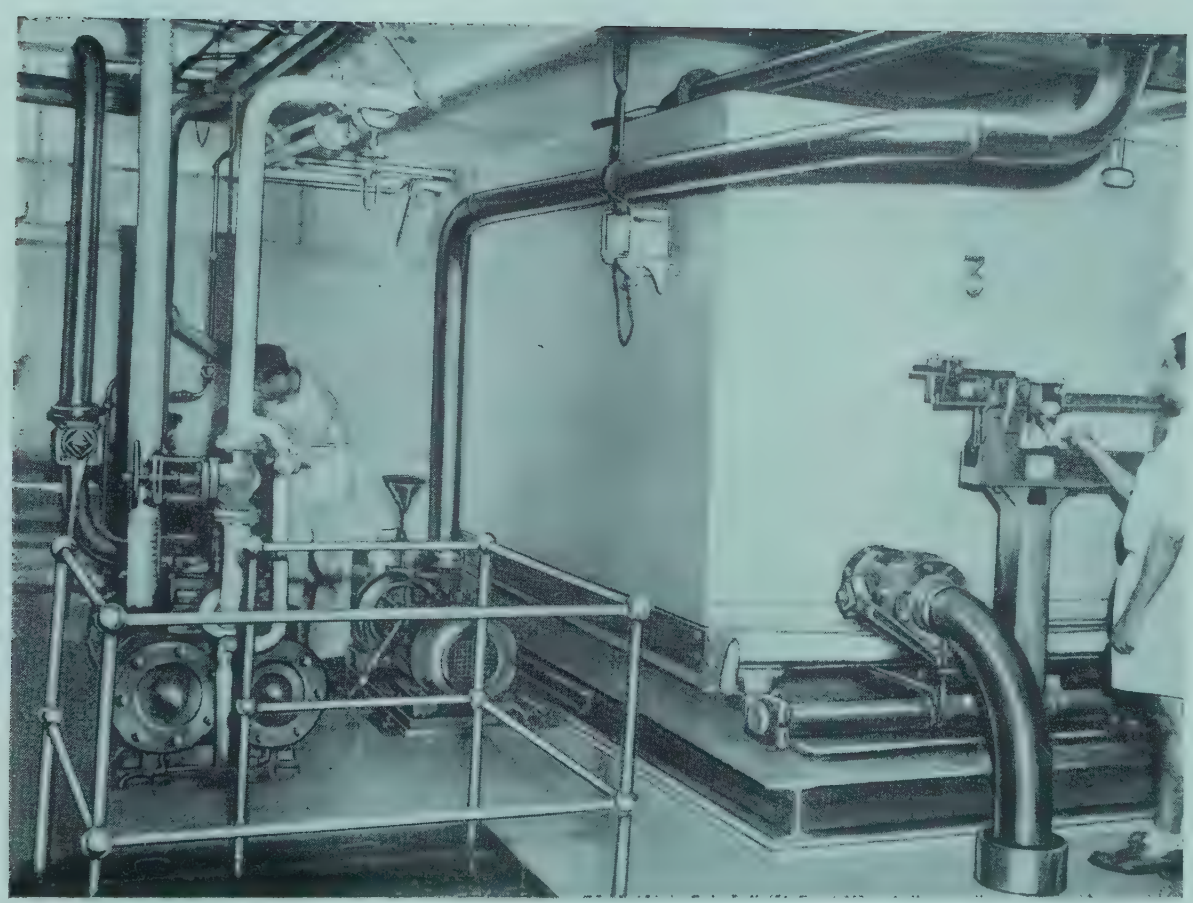


PLATE 12: WEIGH TANK AND RAW OIL PUMPING INSTALLATION
(The Hindustan Vanaspati Manufacturing Company Private Limited, Bombay)

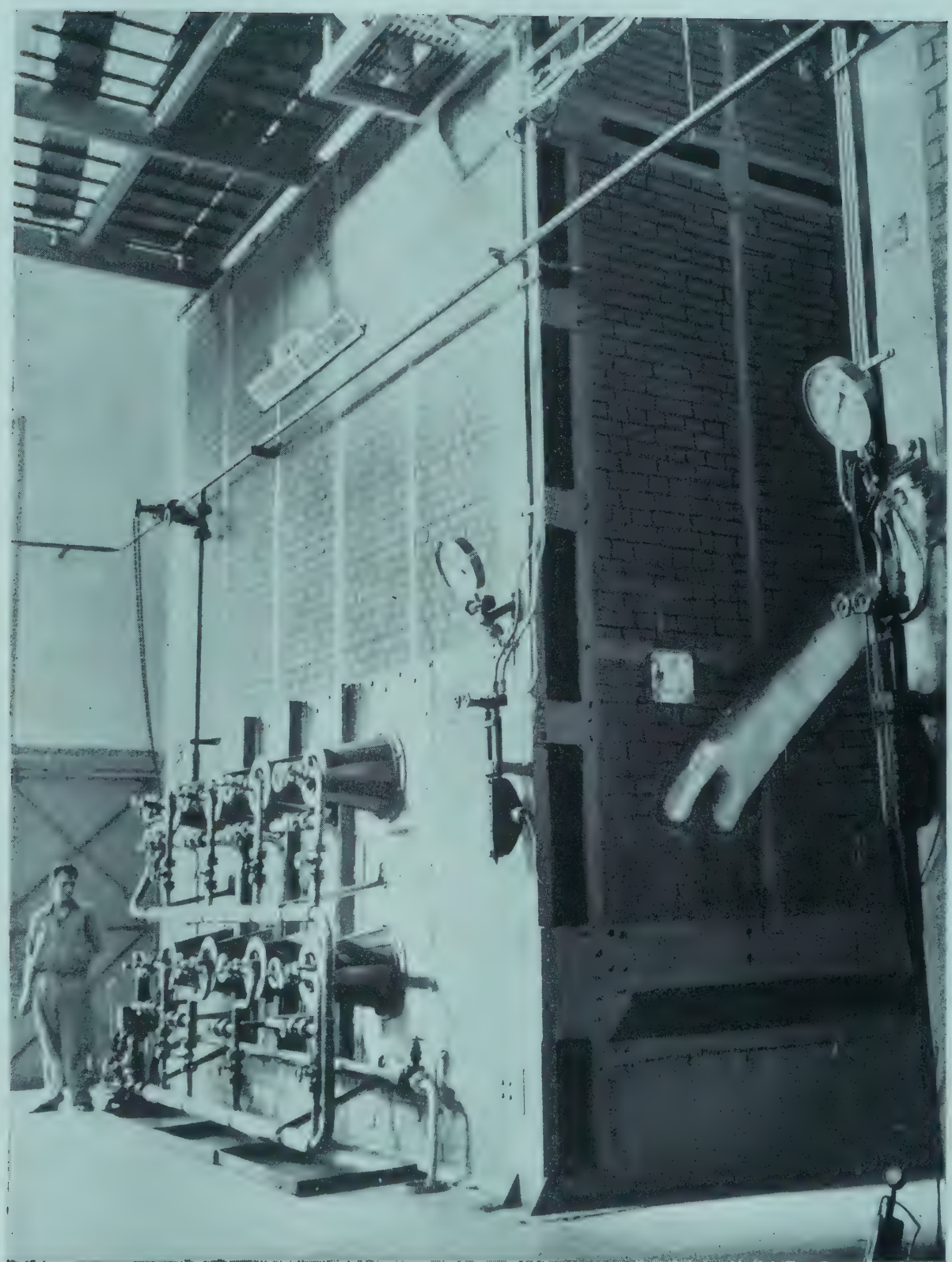


PLATE 13: BOILER HOUSE
(The Hindustan Vanaspati Manufacturing Company Private Limited, Bombay)

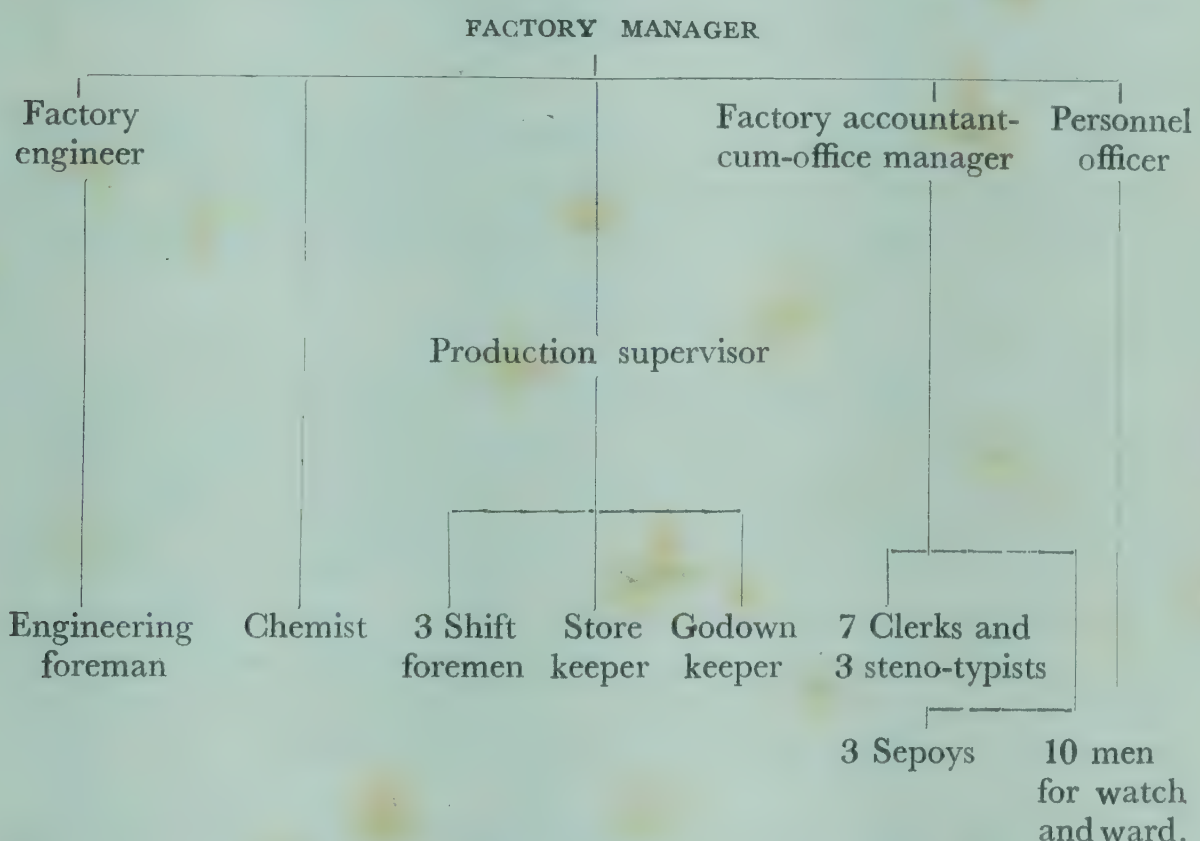
CHAPTER IV

PRODUCTION CONTROL AND FACTORY ADMINISTRATION

In addition to the actual manufacture of vanaspati, there are various aspects of production control and factory administration which are of significance. The more important of these are discussed below.

(a) Factory Management

The management structure and responsibilities vary considerably in the different vanaspati factories in India. In a factory with a production capacity of about 25 tons of vanaspati per day, a typical organisation chart is as under:



The labour force of a factory of this capacity numbers about 150.

The factory manager, with the aid of his departmental heads, plans production for the requirements of the market based on the availability and quality of raw materials, the standards of quality required for finished products, plant capacities, operation methods and time cycles. To achieve his production plan, he has to exercise control on the following factors:

(1) Flow of raw materials, chemicals and packing materials.

(2) Progressing of production operations.

(3) Quantity and quality of materials and products.

(4) Allocation and efficient application of labour.

(5) Maintenance of plant and buildings.

(6) Despatch of finished products.

The purposes of production control are the provision of products of good quality at the most economic cost in the required quantities at the required time. This necessity for control is not associated with the size of the undertaking. It is as much present in a small unit as it is in a factory employing 1,000 hands. The essential difference is in the technique and mechanism used in the various concerns to carry out the functions of planning and control.

(b) Labour

The vanaspati industry provides employment directly to about 10,000 people and a much larger number indirectly, and the vanaspati factories are subject to the same general Government laws and rules as other factories.

(c) Factory Layout

The main object of a planned layout for a factory is to expedite production by reducing internal movement from one operation to the next as much as possible. Thus, those items of plant must be placed next to each other which perform successive functions on the same piece of work so that the work may flow easily and speedily from one plant to the next with perfect continuity of operation from raw material to finished product. In the case of industries, such as the vanaspati industry, which manufacture one product in a continuous stream, it is obvious that the raw materials should be introduced at one end and the finished product should issue at the other.

The actual layout for each vanaspati factory will depend entirely on individual circumstances, but certain fundamental points are common to all. For example, the raw oil storage tanks, process material stores and the warehouse for finished products should be situated close to a railway siding and should also be accessible by road. The factory layout should be U-shaped, with the refinery (refining, hardening and deodorising plant) along one "leg", and the packing department, cooling rooms and warehouse along the other which terminates at the railway siding. The boiler house, soapstock splitting station and hydrogen generator should be reasonably close

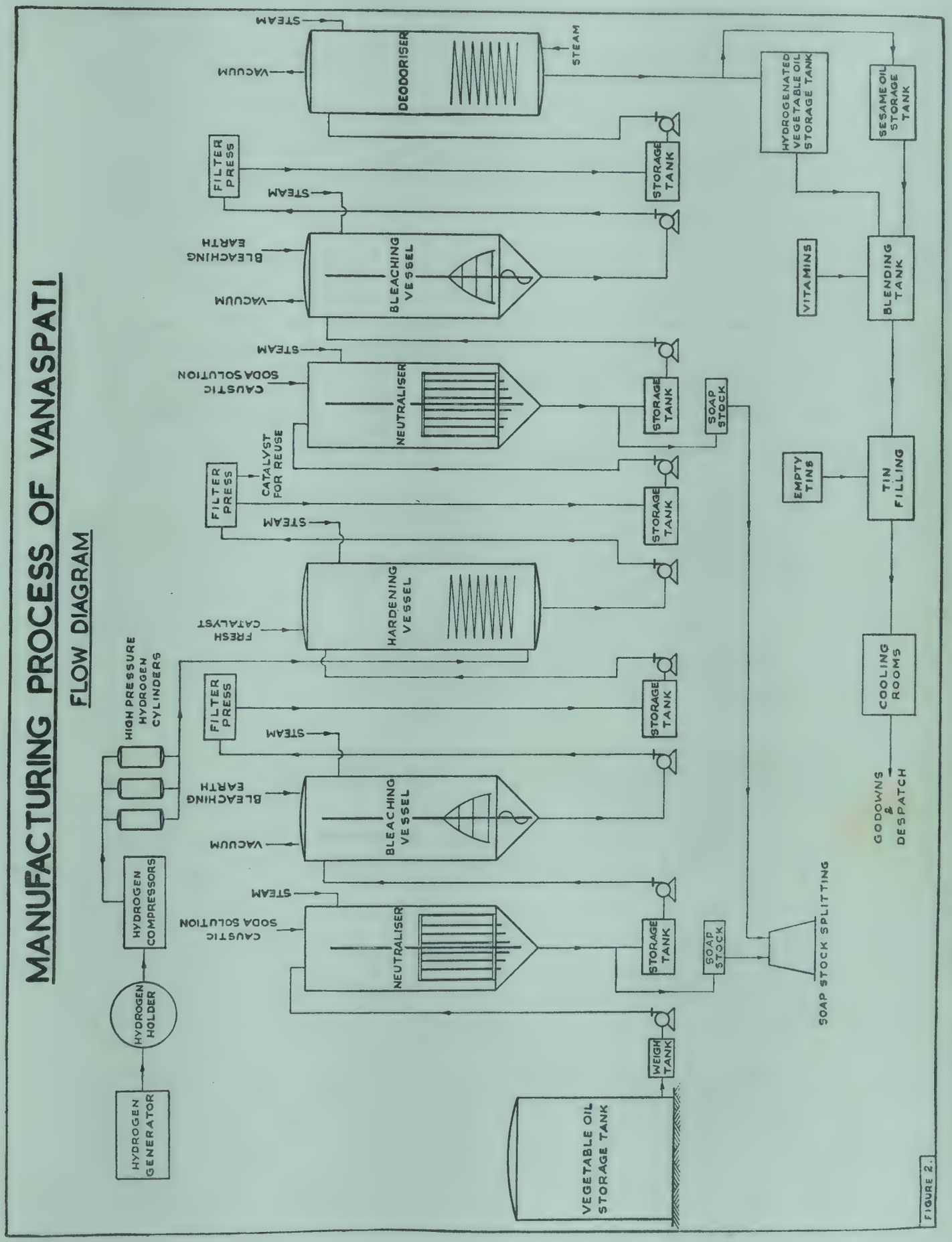


FIGURE 2 : MANUFACTURING PROCESS OF VANASPATI—A FLOW DIAGRAM

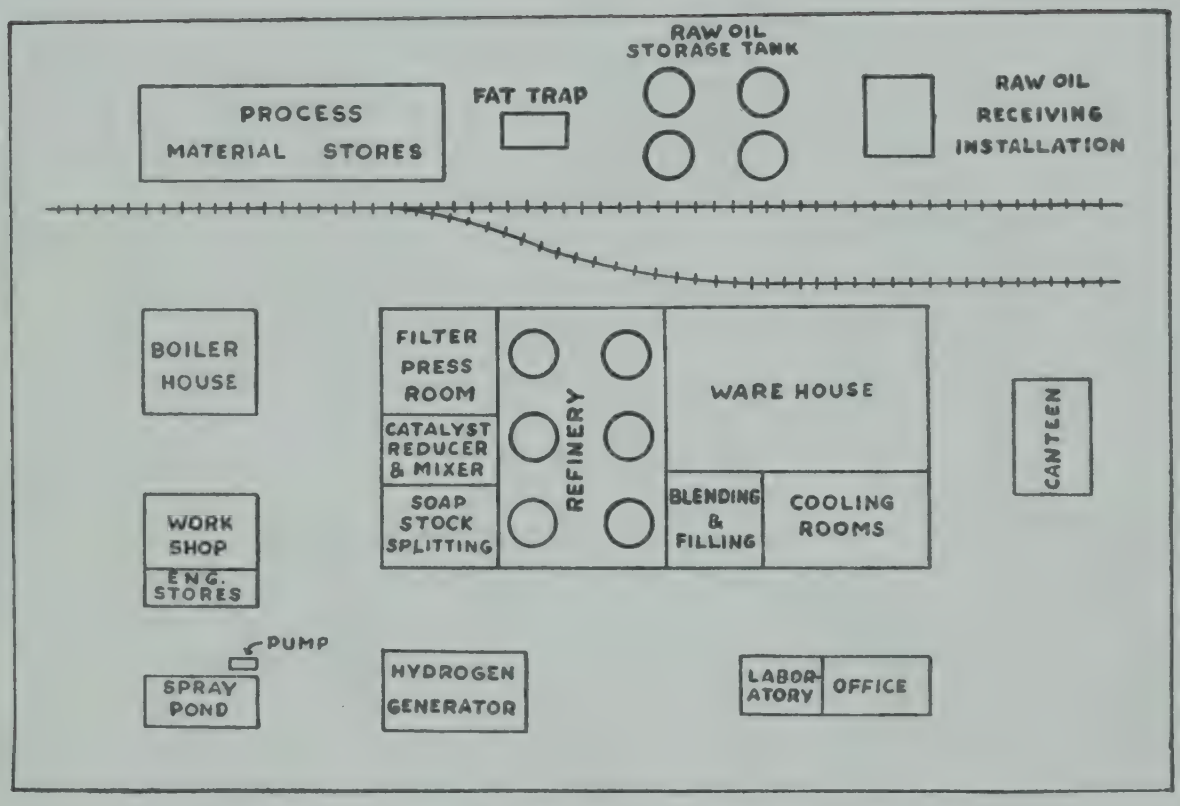


FIGURE 3 : TYPICAL LAYOUT OF VANASPATI FACTORY

to the refinery, but the actual positioning of the workshop, laboratory and administrative offices is a matter of convenience. A diagram of the flow of work in a vanaspati factory is shown in Figure 2, and a typical layout is shown in Figure 3.

There are numerous Government rules and regulations regarding the erection of buildings and plant. Those which are related directly to vanaspati factories are summarised below:

(*i*) *Building regulations:* No new building can be constructed, or an old building re-erected, without prior permission from the Director of Industries of the State and the local Municipality, whose approval of the actual designs must also be obtained. The Director of Industries exercises controls on materials of construction. The Bombay municipal regulations stipulate that (*a*) the external walls and roof of buildings should not be of inflammable material, and also that an efficient fire-fighting service should be maintained, (*b*) there should be a minimum clearance of 10 feet between any two buildings in a factory, and (*c*) the heights of buildings should not be beyond the prescribed limit of 70 feet. Similar regulations are enforced by other municipalities in India.

(*ii*) *The Factories Act, 1948,* contains, among other things, numerous provisions to safeguard the health, safety and welfare of industrial workers. For example, Section 31 (1) of the Act stipulates that

> "If, in any factory, any part of the plant or machinery used in a manufacturing process is operated at a pressure above atmospheric pressure, effective measures shall be taken to ensure that the safe working pressure of such part is not exceeded."

Boilers and autoclaves come within the purview of this Section. Hydrogen and the equipment relating to its manufacture, storage and utilisation, are not specifically mentioned in Section 37 which is entitled "Explosive or inflammable dust, gas, etc.", but they may be considered to come within its scope. The precautions to be taken in the case of fire are enumerated in Section 38.

(*iii*) *The Petroleum Rules, 1937,* state that fuel and diesel oils come within the definition of "heavy petroleum" (petroleum which has its flashing point not below 150°F). Rules relating to the storage of petroleum are prescribed under Sections 90 to 108, and some of the important portions are reproduced below:

"100. *Construction of tanks:*

(1) Every tank or other receptacle used for the storage of petroleum in bulk, other than a well-head tank, shall be constructed of iron or steel, properly erected and designed according to sound engineering practice; and, together with all pipes and fittings, shall be so constructed and maintained as to prevent any leakage of petroleum.

(2) The height of a storage tank shall not exceed its diameter provided that in the case of tanks of less than 30,000 gallons capacity the height may extend to one and half times the diameter.

(3) No tank shall be more than 50 feet in height.

106. *Pumping:* No internal combustion engine or electric motor shall be used for driving pumps for pumping petroleum save in a pump house specially constructed for the purpose and under such conditions as may be approved by the Chief Inspector.

Provided that this rule shall not apply where the motor, control switch gear and starting apparatus are of flame-proof construction satisfying the requirements of British Standard Specification No. 229.

109. (*1*) *Exemption of heavy petroleum storage*: Notwithstanding anything contained in these Rules, it shall be permissible to store without licence, subject to the conditions of this chapter, heavy petroleum in quantities not exceeding 10,000 gallons which is not stored in the same installation or storage shed as other petroleum.

110. (3) A distance of not less than 10 feet shall be kept clear between protected works and the enclosure walls or banks."

(*iv*) *The Indian Boiler Regulations, 1950*, contains 534 provisions, almost all of which are important and worth studying. Rule 378 provides that every boiler shall be hydraulically tested in the presence of an Inspector or Inspecting Officer.

(d) Food Laws

The most important food legislation which relates directly to the vanaspati industry is the Vegetable Oil Products Control Order, 1947 The genesis of

this Order has already been given in chapter I, and the entire Order, as amended upto December 1955, is given in Appendix C. The specification for vanaspati is given in S. R. O. 780 dated 21st October, 1950. Briefly, the V. O. P. Controller requires that :

(1) each oil (except *sesame*) used in the manufacture of vegetable oil product should be individually hydrogenated, or all the oils (except *sesame*) should be mixed and the mixture subjected to a process of hydrogenation;

(2) vanaspati should not contain any colouring or flavouring matters resembling those of ghee;

(3) vanaspati should conform to prescribed limits for melting point, moisture content, butyro-refractometer reading, unsaponifiable matter content, free fatty acid content, and Baudouin colour reading; and

(4) vanaspati should contain not less than 5 per cent by weight of raw or refined *sesame* oil, and not less than 700 I. U./oz of synthetic vitamin A.

According to S. R. O. 780, the melting point of vanaspati as determined by the capillary slip method shall be from 33° to 37°C. The V. O. P. Controller, however, grants permission to individual factories to manufacture vanaspati (*i*) with a melting point of 31°C, during winter for despatch to specified destinations, and (*ii*) with a melting point of upto 41°C, if it is intended for sale to biscuit manufacturers only.

In the case of vanaspati supplied to the Defence Services, A. S. C. Specification No. 139 (N. S.) is applicable. This specification (cf. Appendix D) very closely resembles the one specified by the V. O. P. Controller in S. R. O. 780, but the special features of the former are that :

(1) it permits vanaspati to be suitably flavoured and prescribes that diacetyl shall be one of the constituents; and

(2) the melting point as determined by the capillary tube method shall be 37° $\pm$ 2°C.

The Prevention of Food Adulteration Act, 1954, and the Prevention of Food Adulteration Rules, 1955, have been published recently. These supercede the Prevention of Food Adulteration Acts and Rules which were in force in different States before the enactment of the present Act and Rules. The Rules give, among other things, definitions and standards of quality,

rules regarding the use of colouring matters, packing and labelling rules, and conditions for sale and licence. Although the Prevention of Food Adulteration Rules, 1955, have already been published, certain sections are still being reviewed by the Central Committee for Food Standards.

(e) Taxation

The cost of vanaspati in relation to that of oil is much higher than what it should be on the basis of the cost of processing because of the heavy burden of taxes. Vanaspati is subject to excise duty levied by the Government of India, sales tax at varying but high rates in different States, and town duties which are sometimes discriminatory. The difference in the prices of vanaspati and its own raw material, namely vegetable oil, is thus largely due to taxes. In 1955, taxes of all kinds accounted for as much as 30 per cent of the prevailing prices of vanaspati in some places.

In 1943, the Government of India announced that an excise duty of Rs. 100 per ton would be levied on vegetable product which was defined as "any vegetable oil or fat which, whether by itself or in admixture with any other substance, has by hydrogenation or by any other process been hardened for human consumption." In 1948, the duty was raised to Rs. 140 per ton. Under Central Excise Rule 8(1), vegetable product is exempted from excise duty if the Collector of Central Excise is satisfied that it is intended for use in the manufacture of (*a*) soaps, including insoluble soaps, (*b*) fatty acids, (*c*) greases, lubricants, and textile and sizing agents, or (*d*) protective agents for tin-plate.

According to the Finance Bill, 1956, an excise duty is being levied on vegetable oils. Thus the tax burden on vanaspati is increased by Rs. 70 per ton of oil.* Furthermore, vegetable oils are now subject to sales tax at an average rate of 3 per cent.

The sales tax on vanaspati varies in different States from $4\frac{1}{2}$ per cent to $6\frac{1}{4}$ per cent, and the town duties are as much as 1 anna per lb. in some towns.

The total tax burden on vanaspati is high, as the figures in Table 11 show.

Table 11: Estimated Revenue from Vanaspati Manufactured in 1955

Duty or tax	Revenue (In crores of Rupees)
Excise duty @ Rs. 140 per ton	3·5
Sales tax @ 5 per cent (average figure)	2·0
Octroi and terminal taxes, licence fees, etc.	1·0
Total ..	6·5

* The Finance Bill, 1957, proposes to increase the excise duty on vegetable oils to Rs. 112 per ton.

In the current year, the excise duty on the oils forming the raw materials of the industry will furnish a further sum of rupees two crores to the exchequer. To add to the burden of the already high tax-structure, there is the recent announcement by the Railway Board that the transport of non-essential vegetable oils and vanaspati will be subject to higher freight charges.

(f) Raw Materials

The basic raw materials required for the manufacture of vanaspati are groundnut oil and *sesame* oil. According to the Second Five-Year Plan, the target for the production of vanaspati in 1960-61 is 400,000 tons and, in order to achieve this target, approximately 410,000 tons of groundnut oil and 21,000 tons of *sesame* oil will be required. No particular difficulties should be encountered in procuring these tonnages of the two oils. Currently, cottonseed oil is not available in sufficiently large quantities and at an economic price but, when it does become available, as envisaged in the Second Five-Year Plan, the requirement of groundnut oil will be proportionately reduced.

In addition to vegetable oils, there are several processing and packing materials which are required for the manufacture and marketing of vanaspati, and the estimated requirements based on current consumption are given in Table 12.

Table 12: Approximate Requirements of Various Sundry Items

Item	Requirements for 400,000 tons of vanaspati
Caustic soda	2,000 tons
Bleaching earth	5,100 tons
Activated carbon	340 tons
Nickel formate	240 tons
Filter cloth	240,000 sq.yds.
Tin plate	33,800 tons
Coal	200,000 tons

The caustic soda requirement is not very large, and no difficulties should arise in procuring the material used for alkali-refining. A small quantity of pure caustic soda is used in the manufacture of electrolytic hydrogen ; the specifications for this material are as follows:

NaOH	(minimum)	99·00 per cent.
NaCl	(maximum)	0·25 per cent
Na_2SO_4	(maximum)	0·05 per cent

These specifications are rather stringent, but caustic soda of this grade can be obtained from local manufacturers.

At present there are four factories in India engaged in the manufacture of bleaching earths. It is estimated that approximately 1500 tons of indigenous bleaching earths were manufactured in India during 1955 as compared to a total installed capacity of approximately 2000-2500 tons. The production of bleaching earths is far below even the present requirements of the industry, and considerable quantities of this material are therefore imported. There are plans for the erection of two more factories in India during the near future; although details regarding these production units are not available, it seems unlikely that the requirements of the vanaspati industry can be met from local sources only. There is another aspect to be considered, namely, the quality of the bleaching earths. It has been the experience of several vanaspati manufacturers that the quality of the indigenous bleaching earths is far below that of the imported earths. It is possible that the work initiated by the Indian Standards Institution might improve the position of the bleaching earth industry in India, but imports of this material of the quality required for bleaching difficult oils, for example cottonseed oil, may have to continue for several more years.

There are no reliable data regarding the use of activated carbons, and the figures given in Table 12 should perhaps be taken with some reservation. There is hardly any activated carbon manufactured in India, and practically all the requirements are met by imports.

Nickel catalyst, either in the form of nickel formate or the supported catalyst, is imported. There is no indigenous manufacture of this material, but a unit has been set up recently in Bombay for recovering nickel from spent catalyst.

The filter cloth position is relatively satisfactory inasmuch as a sufficient yardage of suitable quality material is produced within the country. During the last two years, filter cloths made from nylon and other synthetic fibres have been marketed in this country. These are imported and are believed to have a much longer life than the normal cotton filter cloths. Beyond use on an experimental scale, the present consumption of these nylon filter cloths is negligible.

The tin plate position is not altogether satisfactory. In 1954, approximately 67,000 tons of tin plate were produced in India and about 8,000 tons were imported. The requirements of the vanaspati industry alone are about

two-fifths of the total figure. In view of the shortage of tin plate, the Government of India have allocated a quota to the vanaspati manufacturers, according to which 7·5 per cent by weight of tin plate may be used for packing vanaspati in 36 lb. tins, and 13 per cent by weight of tin plate may be used for packing vanaspati in tins of 10 lb. capacity or less.

Although the quantity of coal required by the vanaspati industry is not very large, the manufacturers frequently face acute shortages because of inadequate transport facilities. With an increase in the rolling-stock, this position should improve.

(g) Utilisation and Disposal of By-products

The main by-products of the vanaspati industry are soap-stock and wash waters, spent bleaching earth, spent nickel catalyst and oxygen. Soap-stock and wash waters are obtained during the process of alkali neutralisation of the raw and hydrogenated vegetable oils, and spent bleaching earth is left over after the bleaching process. Fresh nickel catalyst has a certain degree of activity which is progressively reduced when it is utilised for hydrogenating successive batches of vegetable oil, and a stage is reached when the time taken for hydrogenation is so long that it is uneconomic to use the catalyst; this is known as spent nickel catalyst. Oxygen is obtained as a by-product during the manufacture of hydrogen by the electrolytic process, a method which is used by the majority of vanaspati manufacturers in India.

Soap-stock contains a fairly high proportion of fatty matter, the actual amount varying according to the free fatty acid content of the oil and the strength of caustic alkali used in the neutralisation process. It usually varies from about 20-50 per cent, the remainder being chiefly water. Almost all the soap-stock produced in the country is used for soap-making purposes. If a soap factory is situated reasonably close to the vanaspati factory, it is the usual practice to transfer the soap-stock in a tank-lorry, but if the soap works is situated far away, it is uneconomic to transport this dilute soap and consequently, it is either grained to yield a soap with a higher total fatty matter content or, alternatively, it is split with mineral acids, such as sulphuric acid, into a form known as "acid oil". The wash liquors contain a very small proportion of total fatty matter, and hence they are always split with acid; the resultant fatty matter, also known as "acid oil", is used for soap-making purposes. An improvement in the treatment of soap-stock by dispersing protein in it before splitting with acid is described in Indian Patent No. 54039 of 1955.

A process for the recovery of oils and fats from spent bleaching earths is

described in Indian Patent No. 44810 of 1951, but it does not appear to have found application in the vanaspati industry. Some vanaspati manufacturers sell the spent bleaching earth at a reasonable price, and the persons who purchase it mix it off with soap-stock or cheap oils, saponify the entire mixture, and sell it as an inferior quality soap. A fairly large quantity of such soap is manufactured in the country, and this has been recognised by the Indian Standards Institution who have prescribed a specification for this grade of laundry soap (Grade IV) in IS : 285-1951.

Although the vanaspati industry was instituted about a quarter of a century ago, it was only recently that the question of recovering nickel from spent catalyst attracted the attention of scientists and technologists in this country. Spent nickel catalyst contains about 4-14 per cent nickel and 45-85 per cent fat, the balance being siliceous matter. A method for the recovery of nickel from spent catalyst by first converting the nickel into sulphide, then to monoxide, and finally to metallic nickel, has been suggested by Ramaswami [98] but the method does not appear to be easy to manipulate. Trials conducted at the Bombay University Department of Chemical Technology have shown that 93-98 per cent of nickel in spent catalyst can be recovered by digesting it twice with a mixture of 20 per cent sulphuric acid and 70 per cent nitric acid. [41] Experiments conducted at the National Chemical Laboratory, Poona, have shown that nickel recoveries of a similar order are obtained by subjecting the spent catalyst to three successive digestions with 1 : 1, 1 : 2 and 1 : 3 solutions of hydrochloric acid. The optimum conditions for the large-scale recovery of nickel and oil from spent catalyst have also been reported by them together with the economics of the process evolved. [43,46] The recovered nickel in both these investigations can be re-used in the form of precipitated carbonate or formate. The recovery of nickel from spent catalyst, based on the work conducted at the Department of Chemical Technology, has been patented (Indian Patent No. 48405 of 1953). A different method of utilising spent nickel catalyst, namely grinding it for use as a pigment, is described in Indian Patent No. 48093 of 1953.

Some of the oxygen obtained as a by-product in the manufacture of electrolytic hydrogen is compressed into cylinders and sold for welding, but a fairly large quantity of the available gas is let off into the atmosphere.

(h) Transport

For the efficient working of an industrial establishment, it is necessary that appropriate quantities of the various raw materials are delivered in good time at the factory, and also that the finished products are removed to the

various centres of consumption. Both these aspects involve adequate transport facilities.

Of the basic raw materials required for the manufacture of vanaspati, the major items are vegetable oils and coal. Tank-wagons are the most economical way of transporting oil in bulk. Movement of oil in drums and other small containers involves loss of oil due to leakage (ca. 2 to 4 per cent) as well as depreciation of the containers. Furthermore, the railway freight on such containers is fairly high. For example, if oil were to be moved in tank-wagons instead of in drums from, say, Adoni to Calcutta, it is estimated that an overall saving of about Rs. 70 per ton could be realised ; this would be equivalent to a saving of half an anna per lb., in the cost of vanaspati. It would also save the country thousands of tons of oil which is now lost through leakage. Immediately after World War II, owing to the inability of the railways to carry the traffic offered and the relatively low priority given to the vanaspati manufacturers, the progress of the industry was hindered. The major problem was the movement of oil from the oil-producing centres to the areas in which the vanaspati factories were located. With the increase in vanaspati production, the need for tank-wagons to transport oil has increased. The Railway Board have already received 400 broad-gauge tank-wagons for vegetable oil traffic and have placed orders for 200 more for broad-gauge and 100 for meter-gauge. A certain number of these tank-wagons has been allocated to the vanaspati industry and it is hoped that the transport difficulties which were experienced until recently will be appreciably mitigated, if not eliminated.

Unlike vegetable oil traffic, the transport of coal and packed vanaspati does not require any special wagons, and the difficulties faced by the industry in procuring coal and despatching their finished products are based chiefly on the inadequacy of rolling stock. This is a general problem being faced in the country and is not specific to the vanaspati industry alone.

CHAPTER V

NUTRITIVE VALUE OF VANASPATI

The nutritive value of a fat may be considered from three points of view, namely, digestibility, utilisation, and the effect of various minor constituents present in the fat. All these aspects have been examined in detail by numerous investigators, and the various data have been compared and assessed carefully by Professor Deuel. [6] This chapter is therefore restricted only to those investigations which have been conducted in India on the nutritive value of vanaspati and other edible oils and fats.

Investigations relating to the nutritive value of vanaspati have been conducted in the main under the auspices of two Committees, namely, the Vanaspati Research Planning Committee and the Vanaspati Research Advisory Committee. The former Committee was constituted in 1946 by the Technical Panel of the then Department of Food, whereas the latter was formed by the Council of Scientific and Industrial Research in 1947. An excellent review of the work conducted until 1952 is given in a C.S.I.R. monograph entitled "Investigations on the Composition and Nutritive Value of Vanaspati."

(a) Nutritive Value

In the second decade of its existence, the vanaspati industry was posed with a problem of considerable magnitude; the nutritive value of vanaspati was being questioned by an important section of the public and popular leaders according to whom the product was injurious to health. They held that the production of vanaspati should be discouraged, if not stopped altogether. In condemning the product, they believed that they had scientific reasons: Ray and Pal of the Indian Veterinary Research Institute, Izatnagar, had reported [102] that vanaspati, when fed at a sub-optimal level of nutrition, affected the growth of rats in the second and third generations. Evidence of poor storage of vitamin A in the liver, as also symptoms of vitamin B deficiency consequent on prolonged feeding with vanaspati as the main source of fat, were also reported by the same authors. These results were not in accordance with those reported by other scientific workers, both in India and abroad. However, as the campaign against vanaspati was becoming more intense, the nutritive value of vanaspati was taken up for discussion at a meeting of the Technical Panel of the then Department of Food, held at Delhi in November 1946. In his address to the Panel, the Hon'ble Dr.

Rajendra Prasad, then Member for Food and Agriculture, urged that a comprehensive and critical scientific investigation of the subject be undertaken to obtain definite and conclusive evidence on the basis of which Government could take a decision in regard to the future of the industry. Acting on this suggestion, the Technical Panel formed a Vanaspati Research Planning Committee of scientific workers, representing different laboratories interested in food and nutrition problems, to plan and carry out co-ordinated experiments at a number of centres and to present a precise and authoritative report on the subject.

The Vanaspati Research Planning Committee drew up a programme of studies using both experimental animals and human subjects with special reference to the conditions prevailing in India. This was necessary because although a considerable amount of work had been done in Europe and America on the relative nutritive values of vegetable oils, hydrogenated fats and butter-fat, most of those studies were carried out with experimental animals receiving adequate diets. The majority of the people in India live on poor cereal diets which are characterised by deficiency in several of the essential constituents. It was considered desirable therefore to investigate the role of vanaspati as compared with other fats in animal and human nutrition using the poor rice diet of South India, which is deficient in proteins, minerals and vitamins. The experiments were divided into three parts: (*a*) animal experiments; (*b*) human metabolism studies; and (*c*) institution feeding experiments.

The animal experiments were designed to study the effect of vanaspati as compared with the corresponding raw and refined oils and also with ghee, when fed at 5 per cent level. Five fats were compared, using six different basal diets:

Fats	*Basal diets*
1. Raw groundnut oil	1. Synthetic diet, adequate in regard to protein, minerals and vitamins.
2. Refined groundnut oil	2. Poor rice diet.
3. Vanaspati (m.pt. 37° C)	3. Poor rice diet supplemented with vitamins.
4. Vanaspati (m.pt. 41° C)	4. Poor rice diet supplemented with casein.
5. Cow ghee.	5. Poor rice diet supplemented with calcium.
	6. Poor Bengali diet.

Apart from growth measurements and studies on breeding and lactating capacity of rats, metabolism studies on the utilisation of the fat, protein and minerals were carried out in the different series of experiments. The storage of vitamin A in livers was also studied on the completion of each series of experiments. In most cases, the experiments were continued for three generations.

Human metabolism studies were carried out with adult human subjects receiving oil, vanaspati or ghee as the main source of fat. As in the case of the animal experiments, the poor rice diet formed the basal diet for these studies and the same five fats were compared. Apart from fat metabolism, the influence of ingested fats on the utilisation of dietary protein and minerals was also studied.

The institution feeding experiments were conducted with children under 15 years of age receiving a predominantly poor cereal diet supplemented with about 5 per cent fat in the form of either raw groundnut oil or vanaspati (with a melting point of 37°C). In this case, the comparison was between raw oil and vanaspati only, the main object being to study whether any characteristic clinical symptom which was not observed in the case of oil was noticeable in the case of vanaspati. Metabolism studies were also carried out.

The animal experiments were carried out at four different centres, the human metabolism studies at two, and the institution feeding experiments at three. The work took three years to complete, and the opinions of the Committee based on the conclusions drawn from the experimental work are best quoted in full :

(*a*) "In comparative feeding experiments carried out at 4 different research centres on rats for 3 generations with raw groundnut oil, refined groundnut oil and vanaspati of melting points 37°C and 41°C, the results indicate that there is no deleterious effect produced by vanaspati as compared with raw or refined oil."

(*b*) "Human feeding trials carried out at 4 different centres also indicate that vanaspati of melting point 37°C has no harmful effect as compared with raw groundnut oil."

(*c*) "Feeding experiments with poor rice diets carried out on rats as well as on human subjects at different centres of research have not shown vanaspati of melting point 37°C to have any deleterious effect as compared with raw and refined groundnut oil. It appears that vanaspati of melting point 41°C is absorbed to a lesser extent than

raw groundnut oil and that it may have an adverse effect on calcium utilisation, although definite conclusions cannot be drawn from the limited series of experiments on calcium metabolism. As regards comparative nutritive values of pure ghee, raw groundnut oil, refined groundnut oil, vanaspati of melting point 37°C, and vanaspati of melting point 41°C, the balance of experimental evidence places ghee as the best ; raw groundnut oil, refined groundnut oil and vanaspati of melting point 37°C fall into one group and are next best to pure ghee ; and vanaspati of melting point 41°C comes third in nutritive value."

Prior to the initiation of the above-mentioned experiments, the nutritive value of various oils and fats had been examined in India. The results reported by Roy [104] and Basu and Nath [38] indicated that the digestive co-efficient of hydrogenated groundnut oil was not significantly different from those of ghee or vegetable oils. Nhavi and Patwardhan [80] examined the rates of absorption of butter, ghee, groundnut oil, coconut oil, *sesame* oil and hydrogenated groundnut oil. Butter, ghee and coconut oil were found to be rapidly absorbed, whereas groundnut, *sesame* and hydrogenated groundnut oils were absorbed more slowly. Paul *et al* [87] also found that the relative digestibility of butter fat was slightly greater than that of vanaspati or edible vegetable oils. On the other hand, Fattarpekar and Chitre [59] were unable to find any significant difference in the nutritive value of butter, groundnut oil and vanaspati when experiments were conducted with albino rats for three generations. Bose and Subrahmanyan [48] also arrived at a similar conclusion on the basis of a comparative study of cow ghee, refined groundnut oil and vanaspati (melting point 37°C).

Vanaspati is a product comprising of 95 per cent hydrogenated groundnut oil and 5 per cent *sesame* oil. The former component may be obtained either by the process of straight hydrogenation or by blending oils hardened to different melting points. Such products are normally referred to as straight hardened or blended vanaspati. Sahasrabudhe and Subrahmanyan [116] have found that if the two types of products have the same melting point, there is no significant difference in their digestibility co-efficient or rate of absorption. Furthermore, the digestibility of vanaspati with a melting point of 38°C is similar to that of ghee, coconut oil or refined groundnut oil, namely, approximately 96 per cent. On the other hand, the co-efficients of digestibility of vanaspatis with melting points of 45°C and 51°C are significantly lower, being about 91 per cent and 63 per cent, respectively.

To summarise, all the experimental evidence points to the fact that

vanaspati is perfectly harmless and that, in its nutritive value, it resembles the edible oils from which it is made.

(b) Vitamin A

It was mentioned in the previous section that, about a decade ago, there was considerable agitation against the manufacture and consumption of vanaspati. One of the arguments adduced in condemnation of vanaspati was that it did not contain vitamin A. It is true that the vanaspati which was manufactured prior to 1950 did not contain this vitamin for two simple reasons: firstly, vegetable oils do not contain vitamin A to any significant extent; secondly, until about six years ago, the only industrial source of vitamin A was of marine animal origin and it was felt that such a source of vitamins might offend the socio-religious susceptibilities of the consumer public in this country. During the forties, experiments were under way in Europe and the U.S.A. to synthesise vitamin A and, towards 1950, it was produced successfully on a commercial scale. Synthetic vitamin A is a product in the manufacture of which the starting material used is of vegetable origin, namely, lemongrass oil. This news attracted the attention of the Ghee Adulteration Committee which made a recommendation to the Government of India in November 1952 that vanaspati should be fortified with synthetic vitamin A in order to increase its nutritive value. A similar recommendation was made by the Nutrition Advisory Committee of the Indian Council of Medical Research in 1953.

Prior to this, namely in April 1951, the Vegetable Oil Products Controller for India had specified that any manufacturer who claimed that his product was vitaminised should declare from 1st May 1951 onwards the names of the vitamins (A and/or D) on the labels. Furthermore, he specified that no manufacturer could claim that his product contained the specified vitamins unless the quantity added was not less than 300 I. U./oz of vitamin A and 50 I.U./oz of vitamin D. Effectively, according to this specification, the incorporation of vitamins was optional but, on 11th May 1953, he announced that the fortification of vanaspati with synthetic vitamin A would be compulsory from 1st October 1953, the initial level of fortification being 300 I.U./oz. With effect from May 1955, the obligatory level of enrichment was increased so that the vitamin A content of vanaspati at the time of manufacture is now 700 I.U./oz.

Thus, the present position is that whereas the incorporation of synthetic vitamin A in vanaspati is compulsory by law, the addition of vitamin D is optional. Vitamin A is essential for healthy tissues and for general growth promotion. It is also an important factor in improving general resistance to infection and certain diseases, and lack of vitamin A can lead to deficiency

disorders. This, in fact, was one of the main arguments advanced against the encouragement of the vanaspati industry, but is no longer valid since the product is vitaminised to a sufficient level. According to the Nutrition Research Laboratories, Coonoor, the vitamin A activity of genuine cow ghee is about 570-710 I.U./oz while that of buffalo ghee is 230-290 I.U./oz. From the point of view of vitamin A activity, the nutritive value of vanaspati may thus be considered to be as good as that of cow ghee.

Although margarine and other edible oil products had been vitaminised in western countries for several years, vitaminisation of vanaspati was new to India, and it was considered desirable to investigate the stability of synthetic vitamin A when vanaspati was stored under the temperature conditions prevailing in this country. Furthermore, as vanaspati is used chiefly for cooking purposes and not as a spread, it was considered useful to determine the loss in potency suffered by vitamin A when vanaspati is used in different types of cooking operations. Roy [108] studied the stability of vitamin A acetate in crude and refined groundnut oils as well as in blended and straight hardened vanaspatis. Both the varieties of vanaspati were found to afford greater stability to vitamin A, the straight hardened sample being slightly better than the blended one. More recent experiments [55, 63] have shown that :

(*i*) after six months' storage in sealed containers at temperatures ranging from 28°- 32°C, the loss in potency of vitamin A in vanaspati is about 25-30 per cent ;

(*ii*) the loss in potency of vitamin A is the greatest when vanaspati is used for shallow frying (220°C), considerably less in the case of deep frying (200°C), and almost negligible in the case of cooking by simmering (100°C); and

(*iii*) under any given experimental cooking conditions, the loss in vitamin A potency is considerably higher in the case of ghee than in the case of vitaminised vanaspati. The markedly superior stability of vitaminised vanaspati is attributed to its much lower acid value and peroxide value.

Very recently, Chitre and Khale [56] have shown that the biological activity of synthetic vitamin A in vanaspati, as determined by the liver storage method, is of the same order as that of vitamin A in cod-liver oil.

To summarise, the vitamin A content of vanaspati at the time of manufacture is of the same order as that of pure cow ghee, but vanaspati appears to afford greater stability to vitamin A.

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(c) Iso-oleic acid

During the process of hydrogenation, varying amounts of different iso-acids are formed. These acids have the same iodine value as their corresponding cis forms, but they possess considerably higher melting points. The iso-oleic acid contents of various samples of vanaspati have been reported by different investigators [72,95] as varying from 1 to 60 per cent. These limits are inconceivably wide and perhaps a fairer range would be 20 to 35 per cent.[40]

Bose and Subrahmanyan [49] studied the metabolism of iso-oleic acid on albino rats of different age groups fed on a synthetic diet. The digestibility of iso-oleic acid was slightly lower than that of oil without any added iso-acids. Iso-oleic acid was metabolised normally, its deposition in the body being approximately proportional to its content in the dietary fat. The digestibility of oil, with or without iso-oleic acid, was slightly lower in young than in adult rats. Patwardhan [85, 89] has reported that, in young albino rats kept on an adequate diet with 5 per cent iso-oleic acid as the source of fat, the growth over an 8-week period was significantly higher than on a corresponding diet containing 5 per cent oleic acid. The digestibility of iso-oleic acid was only slightly lower than that of oleic acid, but the albino rats appeared to be capable of utilising iso-oleic acid as efficiently (ca. 94 per cent) as oleic acid for metabolic purposes.

(d) Linoleic acid

Some animals, for example, rats, require in their diet a certain proportion of essential fatty acids, such as linoleic acid, in order to maintain health, but it has not been proved that these are essential for human beings also. The linoleic acid content of vanaspati has been reported by several workers as being 0·5 to 13·4 per cent [95], 0·6 to 4·8 per cent [72] and 0 to 12 per cent.[40] According to the Vegetable Oil Products Control Order, 1947, the incorporation of at least 5 per cent by weight of unhydrogenated *sesame* oil in vanaspati is compulsory. *Sesame* oil contains about 40 per cent of linoleic acid and it is obvious therefore that vanaspati must of necessity contain at least 2 per cent linoleic acid. In other words, the lower limits found by the above-quoted authors must be taken with a certain degree of reservation ; similarly, it seems hardly possible that groundnut oil can be hydrogenated to a melting point of about 37°C with as much as 12 or 13 per cent linoleic acid left unattacked. Perhaps a good average range for the linoleic acid content of vanaspati would be from 2 to 5 per cent. As a matter of interest, it may be mentioned that the average linoleic acid content of pure buffalo or cow ghee is about 4 to 5 per cent.

Effectively, although the role played by unsaturated acids in human metabolism has not yet been confirmed, it may be said that vanaspati has a linoleic acid content comparable to that of ghee.

(e) Nickel

After the process of hydrogenation, vegetable oils are very carefully filtered, and then alkali neutralised, bleached and again filtered. These refining methods ensure that the nickel catalyst is almost completely removed before the vanaspati is packed into tins.

Belekar *et al* [40] have determined the nickel contents of numerous samples of vanaspati and found it to vary from 0·02 to 7·0 parts per million ; it is obvious that the higher limit for nickel content is indicative of defective refining methods.

Phatak and Patwardhan [88] have carried out experiments on the toxicity of nickel when fed at high dietary levels to rats and monkeys. Nickel carbonate, nickel soaps of the mixed acids of refined groundnut oil, and nickel supported on kieselguhr and suspended in oil, were used as the test materials. The dosages tried were 25 mg., 50 mg., and 100 mg., per 100 g. of an adequate ration. Even at the high dosages tested, the growth rate and reproductive capacity in rats were unaffected, and no symptoms of toxicity were evident even after 3 to 4 months' feeding. Similarly, no toxic symptoms were noticed in adult monkeys fed on nickel-containing diets for six months.

(f) Calorific value

In terms of calories, there is hardly any difference between vanaspati and the vegetable oils from which it is made. [117] In the composition of its glycerides, vanaspati, like vegetable oils, does not contain any of the lower molecular weight fatty acids which are characteristic of ghee and coconut oil. Weight for weight, therefore, vanaspati has greater energy value than ghee or coconut oil.

In conclusion, it may be mentioned that almost all the experiments quoted in this Chapter were conducted in India prior to 1953 when vanaspati was not being enriched with vitamin A. Even so, from the nutritional point of view, eminent scientists in this country had found after extensive researches that vanaspati was a wholesome food and that it was as good as the oils from which it was made. With the compulsory addition of synthetic vitamin A at the level of 700 I.U./oz, vanaspati is now nutritionally as good as average cow ghee.

CHAPTER VI

COLOURATION OF VANASPATI

From early days, ghee has formed an important article of diet in India and its use is closely associated with the religious and sentimental background of a large section of the people. In fact, ghee is mentioned in the Vedas from which it can be concluded that it must have been in use even in pre-Vedic times.*

Towards the beginning of this century, there was a gradual but definite shifting of population from rural to urban areas, and the demand for ghee from the latter section became increasingly difficult to meet. The result was that ghee sold in towns and cities was invariably found to be adulterated with different materials, including animal fats. The general problem of the adulteration of ghee was made more specific by a certain section of the public by pointed and vehement attacks against the vanaspati industry. The Government of India were of the view that vanaspati was a wholesome product and perfectly harmless, but they were perturbed because the charges levelled were that a fair proportion of the product was being deliberately misused for purposes of adulterating ghee. The Government were thus interested in finding a suitable visible or latent colouring agent which, when incorporated in vanaspati, would easily distinguish pure ghee from ghee adulterated with vanaspati. The problem was not unlike the one which arose in the butter-producing countries of Europe when the margarine industry was first started. The Governments of some of those countries solved the problem by making the addition of *sesame* oil compulsory by law. The Government of India acted similarly, and the incorporation of at least 5 per cent by weight of raw or refined *sesame* oil in vanaspati was made compulsory by the promulgation of a notification under the Vegetable Oil Products Control Order in 1947. The Government also set up a Ghee Adulteration Committee with the object of ascertaining whether a more direct method could be devised for the detection of the adulteration of ghee with vanaspati. The question of finding a suitable visual or latent colour has engaged the attention of numerous scientists in this country, and the present position is summarised below.

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* Some estimates date the Vedas as far back as 4000 B.C., but according to conservative scholarship, they were written "earlier than 1000 B.C."

(*a*) *Sesame oil :* Notification No. S.R.O. 780 of the Vegetable Oil Products Control Order, 1947, specifies that vanaspati shall contain raw or refined *sesame* oil, not less than 5 per cent by weight, but sufficient so that when the vegetable oil product is mixed with refined groundnut oil in the proportion of 20 : 80, the red colour produced by the Baudouin test shall not be lighter than 2 Red units in a 1 cm. cell on the Lovibond scale. The procedural details for performing the Baudouin test are also specified. The test is based on the following fundamental principles.

Crude *sesame* oil contains two minor constituents, namely sesamolin and sesamin, which are not present in any other vegetable oil. Sesamolin is a glucoside and is rapidly hydrolysed by mineral acids, such as concentrated hydrochloric acid, to yield two substances, sesamol and samin. The equation for the hydrolysis reaction as established by Adriâni [35] is as follows :

$$CH_2O_2C_6H_3OC_{13}H_{13}O_4 + H_2O \rightarrow CH_2O_2C_6H_3OH + C_{13}H_{14}O_5$$

(Sesamolin) (Sesamol) (Samin)

A trace quantity of sesamol is sometimes found in samples of crude *sesame* oil and this is referred to as "free" sesamol. Naturally occurring free sesamol as well as the sesamol obtained by the hydrolysis of sesamolin react with furfural to give a red-coloured condensation product.

As a result of numerous investigations conducted by different workers, it is now an accepted fact that a red colour is formed when *sesame* oil is shaken with concentrated hydrochloric acid and then made to react with a solution of furfural in alcohol. The literature published prior to 1900 on the subject of the Baudouin test has been thoroughly reviewed by Utz [129], and the most recent and complete review on this topic has been published by Budowski and Markley. [52]

Criticisms of the Baudouin test have not been lacking and the question of whether or not furfural alone produces red or purple colours with hydrochloric acid has been debated [122,129]. Actually, no colour is formed with pure furfural in low concentrations in alcohol [70,99]. The specificity of the Baudouin test has been questioned inasmuch as the intensity of the colour is reported to be reduced or completely masked by certain factors and, in some cases, the colour is believed to assume a totally different hue. These factors are summarised in Table 13.

Table 13: Effect of Various Factors on Baudouin Colour

Modification of Baudouin colour	Caused by	Reference
Reduction in intensity	Prolonged heat treatment ..	(47), (64), (121).
	Bleaching with certain acid activated earths.	(47), (61), (64), (75).
	Refining, hydrogenation and deodorisation	(9), (10), (44), (45), (51), (82), (120).
	Development of rancidity	(66),(123),(130),(131), (134).
	Reduction in the concentration of HCL	(57), (61), (70), (103)
No colour	Certain species of the genus *sesamum*	(52).
General variation	Origin, variety and source of seed	(51), (131).
Colour change (violet-blue instead of red)	Rancid *sesame* oil or rancid oil containing *sesame* oil	(36).

Alkali refining, bleaching, hardening and deodorising are manufacturing processes which are employed prior to blending and packing vanaspati. The V. O. P. Controller's specifications are applicable to the product from the stage of packing onwards. Effectively, almost all the factors enumerated above which are alleged to modify the Baudouin colour in one way or another are irrelevant in so far as vanaspati is concerned. The only two exceptions are:

(*i*) a reduction in the concentration of hydrochloric acid which results in a reduction in the intensity of the Baudouin colour ; and

(*ii*) the use of rancid oil containing *sesame* oil which results in an indigo-blue colour being obtained instead of the characteristic red.

Both these factors are related to the Baudouin test but should not vitiate the result if the conditions laid down in the Vegetable Oil Products Control Order are followed strictly.

The method of detecting the adulteration of ghee with vanaspati is relatively simple and the test can be easily performed by the average housewife. It involves shaking equal volumes of melted ghee and concentrated hydrochloric acid to which a small quantity of furfural has been added, and observing whether a pink or red colour is produced. Absence of a pink colour denotes absence of vanaspati in ghee. The problem of further simplifying the Baudouin test is receiving the active attention of the Vanaspati Research Advisory Committee.

Finally, it may be mentioned that the incorporation of 5 per cent of *sesame* oil in vanaspati serves a two fold purpose: firstly, it provides a relatively simple and reliable method for detecting the adulteration of ghee with vanaspati and, secondly, it contributes approximately 2 per cent of linoleic acid which is considered by many to be essential for the maintenance of health.

(*b*) *Visible colours:* Artificial colours are added to foods with the object of making the final product attractive and pleasing to the eye. The suggested colouration of vanaspati has a totally different object: it is to provide a suitable visual colour to vanaspati which will give an indication to the buyer regarding the quality of ghee offered for sale. The problem has been engaging the attention of the Government of India for several years, and some State Governments, notably the Punjab (pre-partition), have even attempted legislation. So far, no suitable colour has been found as it has to satisfy a number of requirements :

(1) It should not affect the quality of vanaspati.

(2) It should not be injurious to health.

(3) It should form a true solution in vanaspati and be such that it can be easily incorporated.

(4) It should not be easily removed by physical and chemical processes.

(5) It should not be repulsive to sight, taste or smell, and should not exhibit adverse carry-over properties.

(6) It should be available in commercial quantities at an economic price.

Numerous natural colours and coal-tar derivatives have been proposed from time to time [90, 125], and these are listed below:

Natural colours	**Coal-tar derivatives**
(1) Alkannet	(1) Yellow AB
(2) Annatto or Bixin	(2) Yellow OB
(3) Carotene	(3) Orange SS
(4) Chlorophyll	(4) Sudan IV
(5) Kamala dye	(5) Sudan MP
(6) Madder	

(7) Paprika

(8) Turmeric or Curcumin

Experiments have been carried out with these and many other colours, but none of them conforms to all the requirements set forth in the preceding paragraph.

(*c*) *Latent colours:* Various fluorescent dyes and latent colours have been suggested [71,125] as suitable for incorporation in vanaspati. Some of these are given below:

Fluorescent dyes:	Fluorescein
	Eosin
	Erythrosine
	Euquinine
Latent colours:	Anthranilic acid
	Phenolphthalein
	Thymolphthalein
Other chemicals:	Butyl borate
	Glyceryl monostearin
	Iodides

Many of these have not been subjected to pharmacological tests and, in any case, none of them appears to have any obvious advantage over *sesame* oil.

To summarise, no visible or latent colouring agent has been found which is more effective in use than *sesame* oil. Even if a satisfactory visible colour were to be found and incorporated in vanaspati, ghee is not likely to escape adulteration. Ghee was adulterated long before vanaspati was sold in India. Ghee is still being extensively adulterated with substances other than vanaspati and, according to a recent report [22] published by the Government of India, 54 per cent of the adulterated samples of ghee had as the adulterants such substances as animal fats and vegetable oils. The adulteration of ghee, or, for that matter, of any article of food, can be eradicated only by a rigorous enforcement of food laws, deterrent punishment to the guilty parties, and the mobilisation of public co-operation and support. Manifestly, therefore, the elimination of vanaspati as an adulterant of ghee by colouring or by any other means will not stop adulteration of ghee.

CHAPTER VII

PRODUCTION, MARKETING AND CONSUMPTION OF VANASPATI IN INDIA

As mentioned in chapter I, the vanaspati industry was started in India in 1930. In spite of numerous vicissitudes, the product has gained popularity with the consumer public, especially in the urban areas, and the figures given in Table 14 indicate the steady increase in the production of vanaspati since the inception of the industry.

Table 14: Production of Vanaspati in India

Year	Production (tons)	Year	Production (tons)
1930	298	1943	90,654
1931	2,394	1944	113,030
1932	3,296	1945	132,627
1933	6,199	1946	142,836
1934	15,345	1947	97,160
1935	17,090	1948	127,664
1936	19,372	1949	154,923
1937	29,731	1950	172,437
1938	37,346	1951	171,851
1939	52,031	1952	190,597
1940	65,658	1953	191,182
1941	86,304	1954	230,749
1942	75,766	1955	260,330

In addition to the manufacture of vanaspati, a certain quantity of oil is hydrogenated for non-edible industrial purposes, chiefly soap-making. It is estimated that the production of industrial hardened oil was 18,000 tons in 1955.

The marketing of any commodity involves a number of aspects in addition to the mere act of selling. In fact, in western countries, marketing has almost become a fine art. Very broadly, marketing may be divided into two phases:

First phase : To ensure (*a*) Quality of product,
(*b*) Suitability of pack, and
(*c*) Adequacy of distribution.

Second phase: To offer wider service to the consumers.

As will be seen from the following paragraphs, the marketing of vanaspati in India is based more or less along these lines.

(*a*) *Quality of product:* Vanaspati is the most carefully controlled processed food in India and it is manufactured according to strict official specifications. It is clean, wholesome and uniform in quality. Vanaspati has certain very definite advantages over oil. For example, it is hygienically prepared; it does not spill; its consistency is essential for certain types of cooking, sweetmeats and baking; it does not sediment in the pan as much as oil; it does not go rancid as quickly as oil. In fact, it combines many of the advantages of ghee at between one-half to one-third the price. Its only disadvantage when compared with ghee and oils is that it does not impart the same flavour to food, but this, as many consumers have come to appreciate by now, is due to Government regulations.

(*b*) *Suitability of pack:* Vanaspati is hygienically prepared and packed in tins, untouched by hand. All the vanaspati manufactured in India has always been sold in sealed tins with a brand name. In this respect, vanaspati is perhaps unique inasmuch as other important food products, such as sugar, tea, ghee, oils, etc. are quite often sold loose. When the vanaspati industry was started in India in 1930, the product used to be packed in bulk 4-gallon tins. With the changing economic and social conditions, the industry felt that there was a need for smaller packs which could be purchased more conveniently; bulk packs involved a larger investment from the housewife's point of view and, with a greater tendency for the splitting up of the old joint-family system, such a large pack would last a small family for many months during which time the product would obviously undergo spoilage. Also, it was felt that the production of vanaspati in smaller containers might reduce its misuse in the adulteration of ghee. The packing of vanaspati in small containers was started towards 1939, and it immediately caught the attention of the consumers. Today, numerous brands of vanaspati are available in 10 lb. and 5 lb. tins, whereas some are packed in as small as 2 lb., 1 lb. and $\frac{1}{2}$ lb. tins. The tremendous popularity of the small packs can be gauged from the fact that, despite higher packaging costs, approximately 15-20 per cent of the total production in 1955 was packed in small containers. The bulk 36 lb. pack is intended chiefly for the Defence Services and large institutions, such as biscuit manufacturers, confectioners, "mithai-wallas", hotels, restaurants and hospitals.

(*c*) *Distribution:* For the successful marketing of a product, it is essential to have an efficient distributing system as a follow-up to the quality of the product and the suitability of the pack. Distribution assumes even greater importance in the case of a food product, such as vanaspati, which should be consumed as fresh as possible because, although it will last for several months, it will naturally lack its original freshness. In spite of difficulties encountered

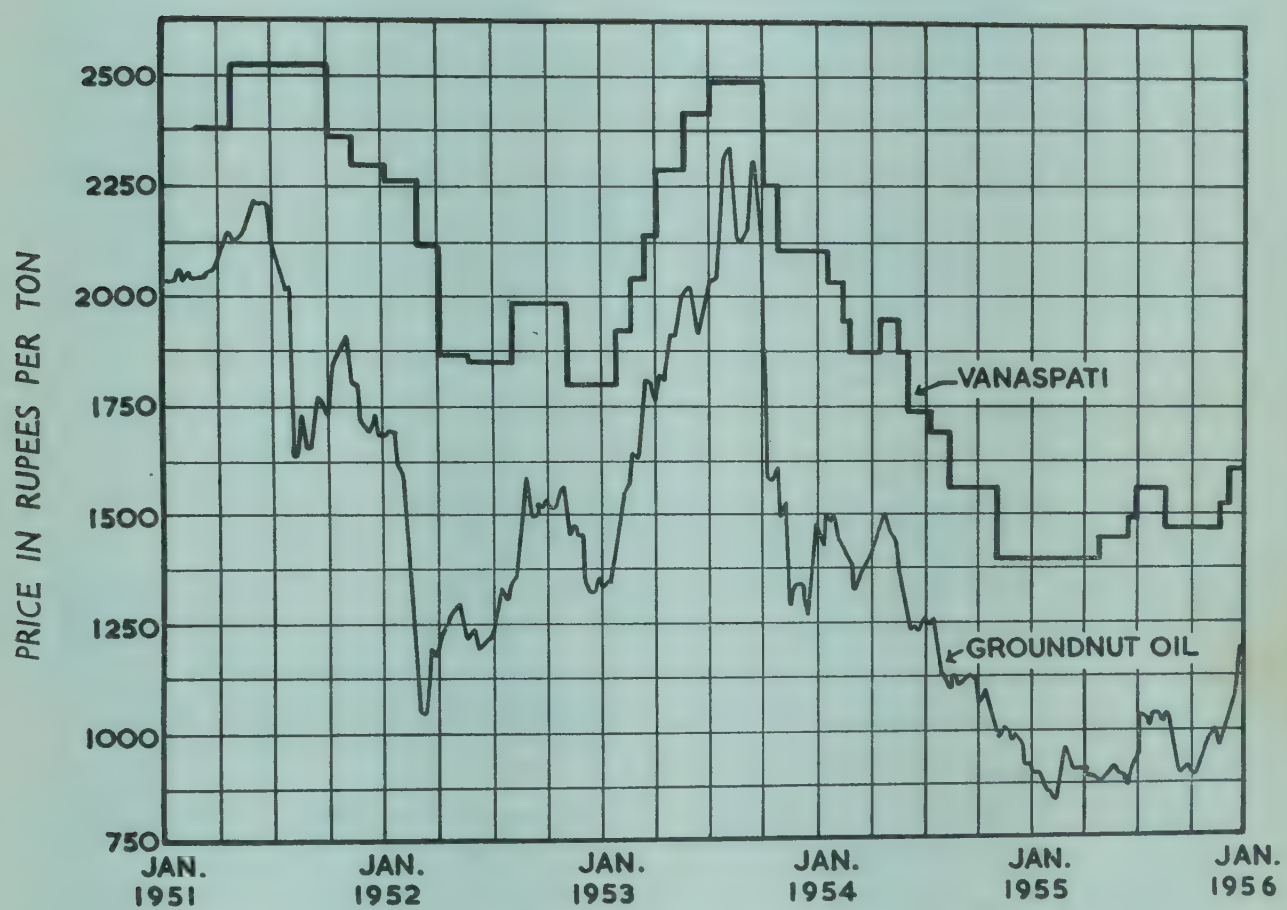

FIGURE 4: VARIATION IN PRICES OF GROUNDNUT OIL & VANASPATI DURING 1951-55

in obtaining suitable quotas of railway wagons, the vanaspati industry has, by and large, succeeded in despatching the finished product to almost every single town and village in the country, thereby ensuring that the product is within the consumer's reach and that he can procure it regularly. Another difficulty faced by the industry is that the prices of the basic raw materials, namely vegetable oils, are subject to wide and frequent fluctuations; despite this, the price of vanaspati has been maintained at a fairly steady level (cf: Figure 4).

It will thus be seen that in the first phase, which is the fundamental phase of marketing, the vanaspati industry has acquitted itself creditably, bearing in mind all the time the interests of the consumer public. In fact, its record is perhaps quite unique in the history of the food processing industries in India.

When an industry has become sufficiently large and popular, marketing views and methods are modified with the object of offering wider service to the consumers and even non-consumers of the product. This is the second phase of marketing and includes:

(*i*) explaining what the product is;
(*ii*) explaining how the product should be used;
(*iii*) demonstrating the use of the product;
(*iv*) offering information on related topics.

In the case of vanaspati, this would mean:

(*i*) explaining the properties of vanaspati vis-a-vis ghee, oils and other cooking fats;
(*ii*) explaining the salient features of good house-keeping and the role played by oils and fats, such as vanaspati;
(*iii*) setting up an experimental kitchen or conducting house-to-house demonstrations;
(*iv*) publishing brochures, pamphlets and books on cooking recipes, nutrition, facts about foodstuffs, healthy diets, etc.

Normally, the result of such service is tremendous goodwill. In Europe and in U.S.A., this phase of marketing is considered to be of much greater significance than the first one, but in India its importance has not yet been fully realised.

There is one final aspect about modern marketing techniques, namely, advertising. The object of advertising is to bring the product to the attention of the consumers and to explain its merits. The vanaspati manufacturers advertise their products individually as well as collectively; in the latter case, the advertisements are issued under the auspices of the Vanaspati Manufac-

PLATE 14: PACKING VANASPATI IN SMALL TINS
(Courtesy: Messrs. Indian Vegetable Products Limited, Bombay)

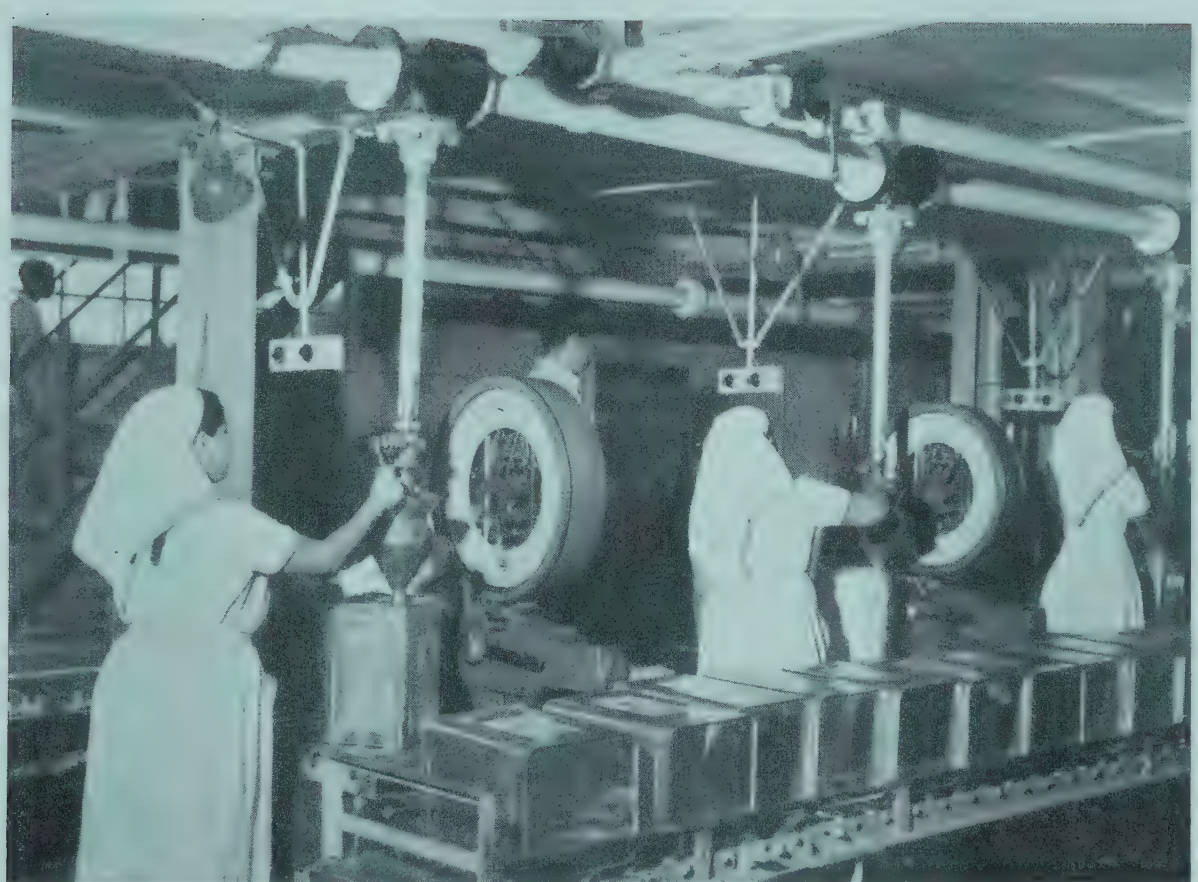

PLATE 15: PACKING VANASPATI IN BULK TINS
(The Hindustan Vanaspati Manufacturing Company Private Limited, Bombay)

turers' Association. Generally speaking, the advertisements are simple and effective, and do not indulge in controversial issues.

The consumption of edible oils and fats in India is largely influenced by climatic conditions. The fertile and colder pasture lands in Northern India produce wheat, millets, milk and ghee. In the warmer tropical climate of the South, the food crops grown are generally rice and oilseeds; there are less pasture lands and, therefore, less milk and ghee. Normally, therefore, ghee is most popular in the North and oils are popular in the South, while their popularity is about equal in the central regions. The vegetable oils consumed are mainly mustard in the North, *sesame* in the South, coconut in the South-West, and groundnut, the cheapest of them all, is consumed wherever people cannot afford the more flavoured oils. The unique contribution made by vanaspati is that it rationalises the vegetable oil resources by converting groundnut oil, the least favoured of all oils, into something which, in a form simulating ghee, is acceptable everywhere.

The regional pattern of production and consumption of vanaspati in India is shown in Table 15. The figures for the consumption of vanaspati indicate that the pattern is very closely similar to the one outlined for ghee in the preceding paragraph: the consumption is very high in the North and decreases gradually to a fairly low figure in the South.

Table 15: Regional Pattern of Production and Consumption of Vanaspati in India during 1952-1955

	Region	Production (Tons)				Consumption (Tons)			
		1952	1953	1954	1955*	1952	1953	1954	1955*
I.	Andhra, Hyderabad, Madras, Mysore and Travancore-Cochin.	20,445	17,997	23,776	24,987	13,573	12,786	14,829	16,925
II.	Ajmer, Bombay, Kutch, Rajasthan and Saurashtra ..	82,500	70,841	83,862	88,527	37,267	36,793	41,315	50,923
III.	Bhopal, Madhya Bharat, Madhya Pradesh and Vindhya Pradesh	15,943	18,173	21,817	25,207	11,658	12,153	14,322	15,546
IV.	Delhi, East Punjab, Himachal Pradesh, PEPSU and Uttar Pradesh	43,844	52,009	61,444	70,121	80,330	76,837	89,472	102,337
V.	Assam, Bihar, Orissa, Tripura and West Bengal	27,865	32,162	39,850	51,488	41,790	41,517	47,251	55,305
VI.	Supplies to Defence Services	—	—	—	—	8,560	7,697	8,528	7,664
VII.	Exports	—	—	—	—	2,451	896	6,840	16,099
	TOTAL: ..	190,597	191,182	230,749	260,330	195,629	188,679	222,557	264,799

* The 1955 figures are estimates.

Note: The slight differences between the figures for the production and consumption of vanaspati in any given year are due to the stock position of vanaspati at the beginning of the year.

The estimated consumption in India of vegetable oils, butter and ghee, and vanaspati is in the proportion of 4 : 2 : 1. The per capita consumption of total edible fats is less than $\frac{1}{2}$ oz. per day which compares poorly with the nutritional requirements of 2 oz. The estimated figures for the production and consumption of hydrogenated and milk fats in some of the countries of the world are given in Table 16. These data also confirm that the level of fat consumption in India is very low. Two other interesting points which are revealed by these data are that (*i*) some of the leading producers of butter in Europe, notably Denmark and the Netherlands, prefer to consume margarine and export butter, and (*ii*) hydrogenated oils are consumed in larger quantities than milk fats in many parts of the world without any obvious injury to health. In this connection, it is interesting to note that, according to the Government of India's report on the marketing of milk in the Indian Union [20], "the recent changes in the matter of utilisation of milk. . . . (due to the) extensive use of vanaspati in cooking in preference to ghee which has become prohibitively costly. . . . (are) developments in the right direction as producers always get a better return when they are able to sell their surplus as milk than when they market milk products."

Table 16: Estimated Production and Consumption of Hydrogenated and Milk Fats in some Countries in 1953

Country	PRODUCTION		CONSUMPTION		PER CAPITA CONSUMPTION	
	Margarine & Vanaspati (tons)	Butter and Ghee (tons)	Margarine & Vanaspati (tons)	Butter and Ghee (tons)	Margarine & Vanaspati (lbs.)	Butter and Ghee (lbs.)
Australia ..	31,750	160,000	27,950	122,250	7·1	30·5
Canada ..	108,500	145,350	108,250	137,800	16·5	20·9
Denmark ..	78,500	170,250	78,150	36,000	40·1	18·5
India* ..	260,000	412,000	265,000	412,000	1·6	2·4
Netherlands ..	198,000	81,800	190,600	28,500	40·8	6·2
Norway ..	79,000	12,500	76,650	12,850	51·6	8·6
Sweden ..	90,000	98,000	89,850	83,850	27·8	25·8
U.K. ..	615,000	15,300	617,650	299,900	26·9	13·1
U.S.A. ..	1,324,700	735,000	1,308,700	614,200	18·4	8·7
U.S.S.R. ..	270,000	357,250	@	@	@	@
West Germany	625,000	283,300	622,100	319,750	28·1	14·0

* The figures for the production and consumption of vanaspati are for 1955, whereas the corresponding figures for ghee relate to 1950.

@ Data not available.

CHAPTER VIII

RECENT RESEARCHES AND LINES OF FUTURE DEVELOPMENT

It will have been observed from the preceding chapters that the process of hydrogenation has contributed significantly to modern oil and fat technology. It is employed on a large scale in the edible fat and soap industries for converting liquid oils into plastic fats, and for improving the resistance of oils and fats to deterioration through oxidation. The chemistry and technology of oils and fats have advanced so rapidly all over the world that it is not possible even to review the modern trends within the span of a single chapter. The Vanaspati Research Advisory Committee of the Council of Scientific and Industrial Research have been producing annually since 1949 excellent publications entitled "Literature Review on Oils and Fats". In 1954, they published a small monograph entitled "Cottonseed and its Products", and they are proposing to publish in the near future a similar volume on the minor oil-bearing seeds and oils produced in India.

It is proposed to discuss in this chapter some of the important researches which have been conducted in India on various subjects related to the vanaspati industry, and brief references will be made to certain interesting items investigated in other countries.

(a) Storage of Oilseeds and Oils

Deterioration of seeds during storage due to heat, humidity and insect attack constitutes a major problem to oilseed growers and crushers. This is particularly so as stocks of seed have to be built up at the time of harvesting so that they are available to the crushers all the year round.

Venkatanarayana [133] has examined in detail the problem of storing groundnut seeds. It appears from his work that (*i*) groundnuts are stored better as pods rather than as kernels; (*ii*) if it is necessary to store groundnuts as kernels for long periods, they should be dried so that the moisture content is below 5 per cent; also they should be properly decorticated so that the percentage of 'splits' and 'brokens' is a minimum; (*iii*) only kernels from the winter (rain fed) crops may be stored for long periods; summer (irrigated) crops have a higher oil content but poor keeping qualities and should therefore be crushed as soon as possible; (*iv*) the kernels should be stored in clean well-ventilated godowns; the bags should be stacked on soft beds, such as of sand, but not more than 10 units high. Rao and Murti [100] have shown

that the phosphatide content of groundnut oil depends on several factors, such as the variety of groundnut seed, the age and degree of ripening of the seeds, the period of storage, etc. It has also been found [53] that the gossypurpurin content of cottonseed oil increases in proportion to the duration and temperature of storage of cottonseed, and this affects the colour of the oil.

Several authors [62,101,128] have examined the stability of crude and refined groundnut and cottonseed oils under different conditions of storage, and found that the deterioration in quality is much greater in the case of metallic containers (galvanised iron, aluminium and brass) than glass. Absence of air or light improves the keeping qualities of the oils. Sahasrabudhe [111] has found that the pro-oxidant effect of metals, particularly copper and brass, is pronounced in the presence of moisture and acidity. The effect of mild steel, tin, galvanised iron, lead and aluminium is not so pronounced. Copper salts have been found to strongly accelerate auto-oxidation. [135] Bose and Subrahmanyan [50] have observed that the rate of development of rancidity in freshly extracted groundnut oil is initially high but diminishes after some time.

(b) Solvent extraction

Almost all the oilseed cake produced in India is used either as manure or as cattle food. The cake is fairly rich in oil content, and it is only during the last few years that efforts have been made to recover some of the oil by solvent extraction. The choice of solvent depends upon a variety of factors, and several investigators have found hexane, trichloroethylene, butanone and alcohol to be quite efficient in use. In India, the choice of solvent has not been easy inasmuch as organic solvents derived from the petroleum industry have to be imported and, furthermore, the relatively high prevailing temperatures would tend to increase solvent losses and fire hazards. On the other hand, the enforcement of prohibition in various States has released large quantities of alcohol for industrial purposes. The use of ethyl alcohol or petrol-alcohol mixtures for extracting oil from cakes has been investigated in detail by Raghunatha Rao. [91,92,93] He finds that 92 per cent of the oil can be removed from the cake by two successive half-hour extractions with hot ethyl alcohol. A recovery of 90-95 per cent oil is achieved by solvent extracting cakes with ethyl alcohol or petrol-alcohol mixtures pre-heated to 50° - 76°C. In general, absolute alcohol has been found, near its boiling point and at atmospheric pressure, to extract 92 per cent of the oil from seed as well as cake. The extracted groundnut oil is of edible grade, but the cottonseed oil requires some refining. In both cases, the defatted cake is fit for human consumption.

(c) Alkali Refining, Bleaching, Hardening and Deodorising

The effect of the concentration of caustic soda, temperature, time of reaction and speed of agitation on the alkali refining of oils and fats has been examined by several workers. Ram *et al* [96] have found that 25 per cent alkali and a temperature of 50°C are the optimum conditions for refining *sesame* oil, whereas a temperature of 60°C and alkali of appropriate strength depending upon the free fatty acid content of the oil are recommended for groundnut oil. Helme and Desnuelle [65] have laid down the optimum conditions for the alkali-refining of groundnut oil as being (*i*) amount of wash water three times that of lecithin present in oil; (*ii*) temperature 80°C; (*iii*) time of contact 45 minutes; and (*iv*) rate of agitation 45 r.p.m. Bhasin and Aggarwal [42] recommend the use of 0·5 per cent excess caustic soda and agitation of the mixture at 400 to 500 r.p.m. in the two-stage alkali-refining of cottonseed oil. A new method for the refining of cottonseed oil by mixing it with caustic soda solution at 24°C, emulsifying it in the absence of air, mixing it with water and heating to 50°C followed by settling, removal of soap-stock, washing and drying, has been described. [124] It has also been recommended [139] that, in refining cottonseed oil, it should be treated with sodium hypochlorite after the process of alkali neutralisation. For refining cottonseed oil with a minimum loss, it has been recommended [54] that caustic soda at 20° Be and a temperature below 85°F should be used; in the case of darker oils, more vigorous agitation is necessary.

Joshi and Saletore [68] have reported the availability in Hyderabad State of a diatomaceous earth which, when activated, has bleaching properties comparable to those of imported earths. Mathur [73] has found that the addition of 0·1 per cent Fuller's earth and 0·02 per cent activated carbon effectively decolorises oils undergoing hydrogenation. He has also reported [74] that the use of activated carbon and Fuller's earth during the process of hardening cottonseed oil permits a saving of about 85 per cent in the quantity of bleaching earth required and also a corresponding saving in the oil retained in the earth. Perhaps the most interesting development is a report [60] that bleaching of cottonseed oil in hexane with activated clay and carbon is not only efficient but involves low oil losses.

The published literature abounds with work conducted by different investigators on various topics related to hydrogenation, such as, types of catalysts, methods of preparing catalysts, methods of hydrogenation, etc. Only a few of these are referred to here. For example, Zajcev [138] has reported a method for the preparation of Ni-Cu catalyst which helps to avoid foaming, reduces nickel consumption, and has a long life and good selectivity.

Nanavati [78] has described different methods for the preparation of nickel catalyst from nickel formate; the best catalyst is obtained by reducing the formate for one hour at a constant temperature of 246°C. Van de Erve *et al* [132] have evolved a new method of hydrogenation wherein dissociated ammonia is used as the gas for hydrogenation. The process consists of five steps: (*i*) conversion of liquid ammonia under pressure to a gas at low pressure; (*ii*) cracking of ammonia at a high temperature and low pressure in the presence of nickel catalyst; (*iii*) removal of residual ammonia from the mixture of hydrogen and nitrogen; (*iv*) compression of the mixed gases; and (*v*) hydrogenation of oils and fats by the use of the mixed gas. Norris *et al* [79] have found that, in oils extracted with trichloroethylene, solvent residues of over 0·003 per cent retard the process of hydrogenation but do not influence selectivity. It has also been found [126] that hydrogenation does not take place in the absence of water provided that it does not exceed 2·5 per cent; with oils of high free fatty acid content, moisture is unnecessary and even harmful.

Beal and Lancaster [39] have examined 13 commercial metals and alloys with regard to their suitability as construction materials for deodorisers, and found many of them to be as good as glass with respect to their influences on the stability of the oil. Aluminium and nickel were found to have the least effect on the stability of oils, iron some effect, while copper was extremely deleterious. Molybdenum reduced the pro-oxidant effect of stainless steel. Zharskii [140] has found that when low temperature steam and low vacuum are employed, the addition of citric acid has no effect on hydrogenated fats undergoing deodorisation.

(d) Antioxidants and stability of vanaspati

Edible oils and fats are prone to develop oxidative rancidity when stored under adverse conditions. In Western countries, where the climatic conditions are favourable and where, owing to shorter distances, the turnover is fairly rapid, the problem of the shelf-life of edible oils and fats does not assume the same large proportions as it does in India where the temperature conditions in different parts of the country are quite severe, long transport hauls are necessary, and storage conditions are relatively poor. The stability of edible fats is thus an important aspect from the marketing point of view.

Butylated hydroxyanisole (BHA), propyl gallate, ethyl gallate, nordihydroguaiaretic acid (NDGA) and hydroquinone are among the well known antioxidants, and their efficacies in stabilising vegetable oils have been confirmed by several workers in India. [58,97,112] Investigations have also been con-

ducted on the antioxidant properties of several indigenous materials, such as, spices and condiments, [113,118,119] wheat germ oil and kamala dye, [58] and aca-catechin from "katha". [67]

Exhaustive pharmacological tests have been conducted on hydroquinone, [136] but its use has not been approved by the Food and Drug Administration of the U.S.A. Propyl gallate [81] and ethyl gallate [107] are reported to be suitable from the physiological point of view. In the United Kingdom, the Ministry of Food permit the use of propyl, octyl or dodecyl gallate, or any mixture thereof, at a level not exceeding 0·01 per cent, and upto 0·02 per cent of butylated hydroxyanisole. [25]

The major component of vanaspati may be obtained either by a process of straight hydrogenation or by blending hardened oils of different melting points. According to the Vegetable Oil Products Control Order, 1947, the final product shall contain at least 5 per cent by weight of raw or refined *sesame* oil and it shall exhibit a melting point within the prescribed limits. The effect of these factors on the stability of vanaspati has been examined by different investigators, mainly under the aegis of the Vanaspati Research Advisory Committee. Roy [109] has found that vanaspati is more stable than unhydrogenated oils and, of the vanaspatis examined, the one with a melting point of 41°C was found to be much more stable than that with a melting point of 37°C. A similar conclusion has been arrived at by Sahasrabudhe *et al* [114,115] who have found that the keeping quality of biscuits can be improved by using vanaspati with a melting point of 41°C instead of the usual one with a melting point of 37°C. With vanaspatis of similar melting point, the straight hydrogenated product is more stable than the blended product.

Improving the stability of vanaspati by the incorporation of suitable antioxidants has engaged the attention of various workers in India. Roy [105] has found that crude *sesame* oil imparts greater stability to vanaspati than refined or hydrogenated *sesame* oil. The same author has reported that whereas the incorporation of citric and tartaric acids, either singly or in combination, at the level of 0·01 per cent does not appreciably improve the stability of vanaspati, [110] 0·005 per cent of ethyl gallate effectively stabilises vanaspati [109] as well as carotene in vanaspati. [106] Sahasrabudhe [112] has examined the effects of BHA, propyl gallate, NDGA, tocopherol, sesamol, lecithin, gum guaiac and hydroquinone at concentrations varying from 0·01-0·1 per cent in refined groundnut oil and vanaspatis with melting points of 37° and 41°C. The synergistic effect of citric acid and the combined effect of some of the antioxidants were also determined. BHA and propyl gallate were found to be the most effective antioxidants when used individually or in

combination with citric acid and lecithin. Sahasrabudhe *et al* [114,115] have found that the shelf-life of vanaspati can be increased by incorporating BHA at the level of 0·015 per cent, and that it can be further improved if a combination of BHA, propyl gallate and citric acid in the ratio of 2 : 1 : 1 is used at the level of 0·02 per cent. Kapadia and Magar [69] have examined the effects of propyl gallate, di-tertiary-butyl-p-cresol, NDGA and BHA when incorporated in vanaspati at levels ranging from 0·01-0·05 per cent. During normal storage, BHA did not afford the same protection as did the other antioxidants and, during frying operations (200°C), none of the antioxidants was effective in use.

Vanaspati has been found to afford greater protection to vitamin A [83] and carotene [106] than unhydrogenated refined groundnut oil. Although the incorporation of synthetic vitamin A in vanaspati is a comparatively recent development, some experiments have been conducted with the object of ascertaining whether the stability of vitamin A during storage and cooking operations can be improved by the addition of antioxidants. Tocopherol and lecithin, [83] iso-butyl gallate, [84] ethyl gallate [108] and BHA [63] are reported to improve the stability of vitamin A in vanaspati, whereas octyl gallate does not appear to be effective. [55] Butylated hydroxy toluene (BHT) is being examined currently, and the preliminary indications are that it is more effective in use than BHA.

(e) Utilisation of Cottonseed and Other Oils

India produces over one million tons of cottonseed per annum, but the cottonseed oil industry is of comparatively recent origin. There are no reliable data regarding the production and utilisation of cottonseed oil, and the figures given in Table 17 are only rough approximations.

Table 17: Production and Utilisation of Cottonseed Oil

Year	Production (tons)	Imports (tons)	Exports (tons)	Used for vanaspati (tons)
1953	8,000	800	Negligible	8,500
1954	10,000	—	1,800	5,100
1955	12,500	—	5,800	500

There are several factors which have impeded the growth of the cottonseed crushing industry in India and also retarded its utilisation in the vanaspati industry. Perhaps, the most important factor is the reluctance on the part of the farmer to use cottonseed cake for feeding cattle, thus rendering it difficult

to find a suitable outlet for the cake. Also, the bulk of the cottonseed crushed in India is not delinted or dehulled, with the result that the benefits which could have accrued from the sale of these by-products are currently not materialised. Until 1952, there was a ban on the export of cottonseed oil, but this was subsequently lifted and, in 1955, no export duty was levied on the oil. The result was that a fairly large proportion of the oil produced in India was exported and its local price was artificially raised and remained high compared to the prices of various competing vegetable oils. For example, in March-April 1956, the average prices in Bombay of cottonseed and groundnut oils were Rs. 1660 and Rs. 1480 per ton, respectively. Cottonseed oil is therefore not likely to be used in large quantities for the manufacture of vanaspati until its price falls to a more realistic level. The Government of India are rightly interested in the development of the cottonseed crushing industry, but if it is intended to utilise the oil locally, it is obvious that the oil should become available to the consumer industries regularly, in sufficiently large quantities, and at a competitive price.

Among the other major oils produced in India, linseed and mustard have been used in the past for manufacturing vanaspati. The Vanaspati Research Advisory Committee are currently investigating the keeping properties and nutritive value of vanaspati prepared from these two oils.

Nigerseed and safflower (*kardi*) are produced in comparatively small quantities and it is estimated that the total production of the two oils is about 40,000 tons per annum. These oils resemble sunflower oil in several respects, and preliminary trials conducted by some vanaspati manufacturers have shown that they are suitable for the manufacture of vanaspati. The difficulty in using these oils is again one of irregular supplies and variable qualities.

The possibilities of producing and using rice-bran oil have been investigated in detail during the last few years at the Central Food and Technological Research Institute, Mysore. From an annual output of about 25 million tons of rice, over 5 million tons of bran and polishings containing about 10 per cent oil are obtainable. Thus, it is possible to produce about 500,000 tons of rice-bran oil per annum in India. On the other hand, since much of the rice is hand-pounded in innumerable small scattered places, the collection of bran will have to be restricted to the rice mills only. Even so, the extraction of oil would have to be done without much delay since the lipase in the rice-bran rapidly deteriorates the quality of the oil: the free fatty acid content of the oil is initially about 3 per cent; within 2 or 3 days' storage of the bran, the free fatty acids increase to 10 per cent, in 10 days to 18 per cent, and in a month to 50 per cent. [94]

(f) Continuous Processing of Fats

In India, the crushing of seeds and the refining, hardening and deodorising of oils are done by the batch process. In Western countries, modern methods using continuously working and automatic equipment are fast supplanting batch equipment. At present, the rated capacity of the vanaspati industry in India is just above the production target set by the Planning Commission for 1960-61. Effectively, although there are no prospects of the setting up of new plants or the extension of existing units in India in the immediate future, the vanaspati industry is likely to expand during the next decade or two. It might be worth while therefore to review briefly the modern trends in the continuous processing of fats.

Continuous plants are installed mainly with the object of producing a material at a lower cost. The factors which usually work in favour of continuous processing plants are as under:

(*i*) automatic control permits losses to be kept at a minimum and the yield of the product to be increased;

(*ii*) automatic control permits the manufacture of a product of constant and dependable quality;

(*iii*) the greater the tonnage handled per operator, the lower is the production cost and, in plants which are automatic and continuous, one operator can handle a very much larger tonnage per shift. Continuous plants are therefore more suited for large outputs.

Continuous plants are now available in Europe and America for the extraction of oil from seeds and for neutralising, bleaching, hydrogenating and deodorising oils; such plants could be erected in India. Continuous plants for the finishing processes are also available, the best example being the Votator which provides a product with a fine satin-like non-granulated texture but does not lend itself to the manufacture of products having a granular texture.

There are several features about continuous plants which have distinct advantages in Western countries but might prove to be the contrary in India. For example, continuous plants can be worked economically only if the output is sufficiently large; the tendency in India has been to erect a large number of small factories. The use of continuous plants involves less labour, but highly qualified technicians are required to operate and maintain them. In Western countries, where labour charges are high and the average standard of technicians is also relatively high, it is advantageous to run continuous

plants. In India, labour is plentiful whereas technicians suitable for manning continuous plants are not easily available. Also, as facilities for maintenance and replacement are generally poor in this country, plants may have to lie idle for long periods in case of breakdown.

In the final analysis, it may be said that whereas continuous processing methods permit the production of larger tonnages of product of uniform quality, the standards of quality are not always as high as those achieved in the batch process. In the case of vanaspati and other edible oils and fats, the quality of the product is extremely important and, whereas the preliminary processes, such as extraction of oil and its refining, bleaching and hydrogenation may be conducted by continuous methods, it is desirable that the final steps involving deodorisation and finishing are done by the batch process.

(g) Prospects of Expansion of the Vanaspati Industry

The birth of the vanaspati industry and its subsequent growth are related to numerous changes in the economic and social conditions which have been taking place in India during the last quarter century. The figures given in Table 18 illustrate the point.

Table 18: Conditions in India during 1911-1951

Item		1911*	1931*	1951
Population of India	(millions)	249	275	357
Literacy	(%)	ca. 3	8·2	16·6
Annual income per capita	(Rs.)	ca. 50	65	280
Occupation: Dependent on agriculture	(%)	ca. 80	ca. 71	70
Non-agriculturists	(%)	ca. 20	ca. 29	30
Towns and cities with population :				
over 10,000		644	792	1,214
over 100,000		29	34	73
Production of vanaspati	(tons)	Nil	2,394	171,851

* Figures computed by deducting those for Pakistan from the total of British India and Indian States.

The two decades from 1911 to 1931 saw a 10 per cent increase in population, a very slight increase in literacy and annual income, and a slight decrease in the population dependent on agriculture with a corresponding increase in the shift from rural to urban environments. In the two subsequent decades, namely from 1931 to 1951, the change in the social pattern was projected

even more clearly. Apart from the phenomenal rise in population and the equally amazing increase in the number of cities and towns, there have been substantial improvements in the standards of literacy and annual income. It will be observed that these two periods of two decades each are immediately previous to and following the birth of the vanaspati industry in India.

Is the consumption of vanaspati likely to expand ? There is not enough information to give an adequate reply, but the general policy underlying the Second Five-Year Plan may be considered to provide an answer. The national income is planned to increase by about 4 per cent per annum. India's fat consumption is very low and experience elsewhere has been that, at least in the initial stages, fat consumption increases slightly faster than the national income. As the allocations for dairy husbandry in the Second Five-Year Plan are low, the production of ghee is not likely to increase sufficiently rapidly during the next few years and hence the increased consumption of plastic fats is likely to be in the form of vanaspati. The present production of vanaspati is about 260,000 tons per annum and as the target figure for 1960-61 set by the Planning Commission is 400,000 tons, it means that vanaspati production will increase during the next five years at the rate of about 11 per cent per annum.

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Appendix A

LIST OF VANASPATI MANUFACTURERS IN INDIA

No.	Name of Manufacturer	Location of Factory
1.	Ahmed Oomerbhoy	Bombay.
2.	Amrit Banaspati Co. Ltd.	Ghaziabad.
3.	Amritsar Sugar Mills Co. Ltd.	Amritsar.
4.	Amrut Oil Mills Ltd.	Bombay.
5.	Aryan Industries Ltd.	Secunderabad.
6.	Ashwin Industries	Samlia.
7.	Berar Oil Industries	Akola.
8.	Berar Swadeshi Vanaspati	Shegaon.
9.	Bharat Vanaspati Products Ltd.	Pachora.
10.	Bhavnagar Vegetable Products Ltd.	Bhavnagar.
11.	Brahmappa Tavanappanavar Ltd.	Davangere.
12.	Davangere Vanaspati Vegetable Oil Co. Ltd.	Davangere.
13.	Delhi Cloth Mills Vanaspati Mfg. Works	Delhi.
14.	East Asiatic Co. (India) Ltd.	Madras.
15.	East Coast Food Products Ltd.	Tadepalli.
16.	Ganesh Flour Mills Co. Ltd.	Delhi and Kanpur.
17.	Government Hydrogenation Factory	Kozhikode.
18.	Hindustan Vanaspati Manufacturing Co. Ltd.	Bombay, Calcutta, Ghaziabad and Tiruchirapalli.
19.	Hindusthan Development Corporation Ltd.	Calcutta.
20.	Hyderabad Vegetable Product Co. Ltd.	Hyderabad.
21.	Indian Vegetable Products Ltd.	Bombay.
22.	Jagdish Industries Ltd.	Porbandar.
23.	Karnatak Vegetable Product Co. Ltd.	Hospet.
24.	Kathiawar Industries Ltd.	Sher Baug.
25.	Kusum Products Ltd.	Rishra.
26.	Lily Oil Industries	Baroda.
27.	Madhusudan Vegetable Oil Products Ltd.	Rakhial.
28.	Madras Vanaspati Ltd.	Villupuram.
29.	Malwa Vanaspati & Chemical Co. Ltd.	Indore.
30.	Margarine & Refined Oils Co. Ltd.	Bangalore.
31.	Mettur Chemical & Industrial Corpn. Ltd.	Mettur Dam.
32.	Modi Vanaspati Manufacturing Co.	Modinagar.
33.	Morvi Vegetable Products Ltd.	Morvi.
34.	Mysore Vegetable Oil Products Ltd.	Bangalore and Madras.
35.	Palanpur Vegetable Products Ltd.	Palanpur.

No.	Name of Manufacturer	Location of Factory
36.	Rohtas Industries Ltd.	Dalmianagar.
37.	S. G. Vegetable Products	Jamna Nagar.
38.	Sewa Singh Gill	Patiala.
39.	Snow White Food Product Co. Ltd.	Calcutta.
40.	Sudarsan Oil Mills Ltd.	Katpadi.
41.	Swaika Vanaspati Products Ltd.	Calcutta.
42.	Swastik Oil Mills Ltd.	Bombay.
43.	Tata Oil Mills Co. Ltd.	Bombay and Tatapuram.
44.	Tungabhadra Industries Ltd.	Kurnool.
45.	U. P. Oil Industries Ltd.	Lucknow.
46.	United Vegetable Manufacturers Ltd.	Calcutta.
47.	Vegetable Products Ltd.	Belghuria.
48.	Vegetable Vitamin Foods Co. Ltd.	Bombay.
49.	Vegetols Ltd.	Chittoor.
50.	Vizagapatam Vegetable Oil Products Ltd.	Bobbilli.
51.	Walchandnagar Industries Ltd.	Walchandnagar.
52.	Western India Vegetable Products Ltd.	Amalner.
	Total number of vanaspati factories	58

Appendix B

LIST OF SOME RECENT INDIAN PATENTS

During the Indian Patent Centenary Celebrations held at Calcutta in March 1956, it was suggested that, with a view to enhancing the value of the patent system, the patents held in India might be classified industry and process-wise. An attempt has been made below to classify some of the recent Indian patents bearing on the vanaspati industry, but it is not claimed to be complete.

Patent No.	Title and short summary.
	(a) Extraction of Oil from Seeds
40058 of 1950.	*Extractor for vegetable oils and a process of extraction :* An extracting chamber, a collecting chamber and a filler between said chambers wherein the extracting chamber constitutes a space between said filler and a foraminated wall disposed concentrically to the two chambers.
42408 of 1951.	*Extracting oil from oil seeds :* A moveable buffer plate fitted at the extension of a screw-threaded pressing rod and stationary plates, and the space in between for housing the oil seeds.
43922 of 1951.	*Improvements in oil expellers :* Comprises an outer chamber with a rotatable inner cylinder containing cage bars for crushing the seeds prior to expulsion.
43154 of 1952.	*Oil extraction process :* Mechanically expressing the material comminuting into fragments, subjecting the fragments to the action of flaking rolls and then solvent extracting such flakes.
44940 of 1952.	*Treatment of seeds for extraction of oil in oil expellers :* Characterised in that tempering chamber is externally heated with hot furnace gases, and oil seeds therein are treated with low pressure steam.
47194 of 1952.	*Improvements in or relating to machine for extracting oil from mustard and like oil seeds :* As oil seed passes the feed end of the machine to its discharge end, it gets crushed between two rotating rollers.
45117 45118 } of 1952.	*Improved process of extracting oil from oil-bearing material :* Extracting the material in aqueous meal with the help of an agent selected from the group consisting of a salt, basic material, demulsifying agent, acid and wetting agent. Extraction in aqueous medium is carried out with the help of steam and an agent selected from the group consisting of a basic material, salt, demulsifying agent, acid and wetting agent.

Patent No.	Title and short summary.

48531 of 1953. *An improved oil ghani or oil mill or grinding mill operated by weight of animal :* Mortar has a circular non-rotating platform, the structure oscillating about a ball and socket joint, and a crusher is hinged to a central shaft which shaft is rotated by a bullock walking on the platform.

46714 of 1953. *A solvent extractor :* Comprising a column having a central rotating shaft fitted with rotating scraper arms which sweep the curved plates provided in the column.

(b) Refining, Bleaching, Hardening and Deodorising

40392 of 1949. *Improvement in the catalytic treatment with hydrogen of glyceride oils :* Hydrogenating the oil above 150°C in the presence of non-colloidal particulate nickel-alumina-silica catalyst having between 15 and 50 per cent by weight of nickel.

40507 of 1949. *Improvement in or relating to the purification treatment of fatty oils containing vitamin A :* Solution of oil in a non-polar hydrocarbon is passed through a column of activated gamma alumina and thereafter the oil is separated from the solvent.

42701 of 1950. *Refining vegetable and animal oils :* Neutralising insufficiently free fatty acids, followed by precipitating pigment and colouring matter by means of strong lye.

43611 of 1951. *A process for improving unsaturated fatty acids or their derivatives :* Heating the material to a temperature below 140°C with a nickel or cobalt catalyst containing sulphur in not more than 10 per cent of the weight of the metal in the catalyst.

44786 of 1951. *A method of decolourising neutralised fatty oils :* Treating neutralised fatty oils with an aqueous solution containing a salt of a strong base and a weak acid.

45080 of 1951. *Refining of fatty oils :* Separating oil after 5 seconds of its contact with 20° Be caustic in turbulent flow.

46579 of 1952. *Hydrogenation catalysts and a process of hydrogenation :* By the use as a catalyst of precipitation product obtained by reacting alkali boro-hydride with a salt of nickel, cobalt or copper.

49358 of 1953. *Improved process for refining vegetable oils and the like :* Vegetable oils containing free fatty acids are treated with soap or soap-stock before or during their refining treatment with alkali solution.

Patent No.	Title and short summary.

49006 of 1953. *Refining of fatty oils and fats :* Adding phosphoric acid to the crude oil, thereafter adding caustic soda to neutralise free fatty acids and separating resulting soap-stock.

48712 of 1953. *Process for the refining of oils and fatty materials and apparatus for carrying out the process :* By mixing crude miscella with a neutralising agent and a solvent substance which dissolves particularly in the solvent of the miscella and in the neutralising agent.

52316 of 1954. *A method of removing impurities from oils and fats :* Subjecting glyceridic oils and fats to superheated steam wherein the amount of steam is substantially twice the quantity of the non-oil constituents of fats and oils.

53947 of 1955. *A method and a device for neutralising fatty oils :* Heating the oil and lye, feeding them separately in the turbulence-causing passages through rotating chamber of centrifuge for part of a second and feeding the mixture from this chamber to separating chamber.

(c) Catalysts

33193 of 1947. *Copper catalysts and their use for hydrogenating organic substances :* Production of copper catalysts by reduction, and their use in hydrogenation in which the heat evolved is dissipated by evaporating surrounding water.

48093 of 1953. *Utilisation of nickel catalyst waste of hydrogenation factories :* Grinding nickel catalyst waste material in an edge runner and using the pulverised mass as a pigment.

48405 of 1953. *Recovery of nickel from spent nickel catalyst :* Recovery of nickel from spent nickel catalyst by the use of formic or acetic acid.

(d) Bleaching Earths

36566 of 1947. *Activated earth.*

39320 of 1950. *Activation of bauxite for bleaching vegetable oils and fats :* A combination of thermal treatment and acid treatment improves the bleaching properties of bauxite with reference to vegetable oils and fats.

Patent No.	Title and short summary.

(e) Nutrition

31570 of 1945. *Vitaminising of oils and fat media, particularly edible oils and cooking fat media :* Heating vitamin containing vegetables in contact with oil or fat.

41335 of 1945. *The improvement of the nutritive value of edible hydrogenated oils such as vanaspati and margarine ;* A process for the improvement of the nutritive value of edible hydrogenated oils by the addition of one or more of the essential fatty acids, namely arachidonic or linolenic acids, and antioxidant (ester of ascorbic acid).

(f) Miscellaneous

30051 of 1944. *A process for the production of fatty acids from waste material such as oil "foots" refuse.*

44810 of 1951. *Process for recovering fats and oils :* Spent earth is treated with an aqueous solution of an alkali or of an alkali metal salt or a combination of these. This treatment may also be carried out in the presence of a detergent.

53887 of 1955. *Improvement in fatty products :* Preparing the emulsion by adding oil to an aqueous phase at elevated temperatures with stirring, the emulsion having dissolved therein a water-soluble emulsifying agent which is sufficiently hydrophilic and lipophilic.

53888 of 1955. *Improvement in emulsions :* By adding oil to an aqueous phase at an elevated temperature with stirring, the emulsion having dissolved therein a water-soluble emulsifying agent containing an anionic or non-ionic capillary active substance of the general formula RXY.

54039 of 1955. *Improvement in the treatment of soap-stock :* Dispersing protein in soap-stock before splitting with acid.

Appendix C

THE VEGETABLE OIL PRODUCTS CONTROL ORDER, 1947

(Amended upto 31-12-1955)

DEPARTMENT OF FOOD (INDIA)

NOTIFICATION

New Delhi, the 9th August, 1947.

No. 2-VP(2)/47. In exercise of the powers conferred by Sub-section (1) of Section 3 of the Essential Supplies (Temporary Powers) Act, 1946 (XXIV of 1946), and in supersession of the Vegetable Oil Products Control Order, 1946, the Central Government is pleased to make the following Order :—

1. (*i*) This Order may be called the Vegetable Oil Products Control Order, 1947.

*(*ii*) It extends to the whole of India (except the State of Jammu and Kashmir).

(*iii*) It shall come into force at once.

2. In this Order, unless there is anything repugnant in the subject or context, —

(*a*) "Controller" means the person appointed as the Vegetable Oil Products Controller for India by the Central Government and includes any person authorised by the Controller to exercise all or any of the powers of the Controller under this Order;

(*b*) "dealer" means a person carrying on business in the purchase, sale or distribution of any vegetable oil product;

(*c*) "producer" means a person carrying on the business of manufacturing any vegetable oil product;

(*d*) "recognised dealer" means a dealer recognized as such by the Controller for the purposes of this Order;

(*e*) "Vegetable Oil Product" means any vegetable oil subjected to a process of hydrogenation in any form, or any preparation thereof for cooking purposes containing not less than 50 per cent of hydrogenated vegetable oil.

3. No producer shall, after such date as the Controller may notify in this behalf, dispose of, or agree to dispose of, or in pursuance of any agreement entered into on or before such date make delivery of, any vegetable oil product except—

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* Inserted by S.R.O. 952 dated 25-11-1950.

(*a*) to or through a recognised dealer, or

(*b*) to a person specially authorised in this behalf by the Controller to acquire vegetable oil products on behalf of the Central Government or of a **(State) Government; and no person other than a recognized dealer shall, after the date notified by the Controller, carry on business in the purchase, sale or distribution of any vegetable oil product.

4. (1) The Controller may by general or special order prohibit or restrict the manufacture, stock or sale of any variety or quality of vegetable oil product, and no † (person) to whom such order applies shall manufacture, stock or sell any vegetable oil product in contravention thereof.

(2) Every producer shall furnish the Controller with such details regarding:—

(*a*) the quantities and varieties of vegetable oil products manufactured by him; and

(*b*) the ingredients used in their manufacture and the sources from which the ingredients are obtained, as the Controller may require.

5. (1) Every producer and every @(dealer) shall comply with such directions regarding the sales, stocks and distribution of vegetable oil products @@(and the maintenance of records relating to the same) as may from time to time be given to him by the Controller.

(2) Every producer and every @(dealer) shall furnish the Controller with such details regarding the quantities and varieties of vegetable oil products produced, stocked or sold by him, during any period as the Controller may require.

6. (1) The Controller may from time to time by notification in the Official Gazette fix, with the prior concurrence of the Central Government, the maximum prices at which vegetable oil products may be sold, and the prices so fixed may be different in different localities and for different classes of transactions.

(2) No person shall buy or sell, or agree to buy or sell, any vegetable oil product at a price exceeding the maximum fixed under Sub-clause (1).

(3) Where in respect of any vegetable oil product a maximum price has been fixed under Sub-clause (1), no such vegetable oil product shall be delivered or accepted, in pursuance of an agreement entered into before such fixing of maximum price and providing for the payment of a price higher than that maximum unless the agreement is so revised as to substitute for the price originally agreed a price not exceeding the maximum fixed under Sub-clause (1).

** Substituted for the word "Provincial" by S.R. O. 952 dated 25-11-1950.
† Substituted for the word "producer" by Notification No. 2-VP (2)/50 dated 18-2-1950.
@ Substituted for "recognized dealer" by S.R.O. 887 dated 11-11-1950.
@@ Inserted by S.R.O. 71 dated 10-1-1953.

7. (1) The Controller may from time to time—

(*a*) allot, with the prior concurrence of the Central Government, quotas of vegetable oil products for the requirements of any specified *(State), area or market;

(*b*) issue directions to any producer or dealer to supply vegetable oil products to such *(State), areas or markets, in such quantities of such types or varieties, at such times, at such prices and in such manner, as may be specified in the direction;

(*c*) require any producer or recognised dealer to keep in reserve stocks of vegetable oil products in such quantities and of such types and varieties as he may direct from time to time.

(2) Every producer and every dealer shall, notwithstanding any pre-existing agreement, give priority to, and comply with, the directions issued to him under Sub-clause (1).

8. (1) No vegetable oil products shall, after such date as the Controller may notify in this behalf, be offered by any person for transport, whether by land or water or accepted by any railway administration or other carrier for transport except under and in accordance with the conditions of a permit issued by the Controller in that behalf ; provided that the above restriction shall not apply to the transport of any vegetable oil product (*a*) not exceeding 5 seers by a bonafide traveller as part of his personal luggage, or (*b*) under and in accordance with military credit notes, or (*c*) under and in accordance with a permit issued by a *(State) authority before the date notified by the Controller or (*d*) in accordance with such general permits as may from time to time be notified by the Controller.

(2) A permit issued in pursuance of Sub-clause (1) shall be returned by the consignor to the Controller, if so required by him, on completion of despatch, or on expiry of the period of its validity whichever is earlier, with the particulars of actual despatches noted on it in such form as may be prescribed by the Controller.

†8-A. The Controller @ may enter upon and inspect and search any premises, vessels and vehicle and seize any stock of Vegetable Oil Products in respect of which such person or persons has reason to believe that a contravention of any of the provisions of this Order has been or is being or is about to be committed.

9. Any Court trying a contravention of this Order may, without prejudice to any other sentence which it may pass, direct that any stock of vegetable oil product in respect of which it is satisfied that this Order has been contravened, to-

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* Substituted for the words "Province" or "Provincial" by S. R. O. 952 dated 25-11-1950.

† Inserted by Notification No. 2-VP(2)/48 dated 9-10-1948.

@ By Notification No. 2-VP(2)/49 dated 17-12-1949, the V.O.P. Controller has delegated these powers to District Magistrates, Deputy Commissioners and police officers of the rank of Sub-Inspector and above. By various other notifications, he has similarly delegated these powers to a large number of State Government officials, mainly in the Civil Supplies and Food Departments.

gether with the receptacles in which the stock is contained, shall be forfeited to (the Government).**

10. Notwithstanding the supersession of the Vegetable Oil Products Control Order, 1946, all notifications, orders and directions issued thereunder shall so far as they are not inconsistent with this Order, be deemed to have been made hereunder and they shall continue in force until rescinded or modified hereunder.

£11. Any law in force in any Part B State except the State of Jammu and Kashmir, corresponding to this Order, by whatever name called, is hereby repealed.

£12. All Notifications, directions and orders issued under this Order which immediately before the 25th of November, 1950, were in force in certain parts of India are hereby extended to and shall be in force in the rest of India except the State of Jammu and Kashmir.

££13. The Controller § may enter and inspect any place where Vegetable Oil Products are manufactured, stored or exposed for sale, and take samples of such articles for examination.

VISHNU SAHAY
Secretary

SPECIFICATIONS UNDER CLAUSE 4(1) OF THE VEGETABLE OIL PRODUCTS CONTROL ORDER, 1947.

In exercise of the powers conferred upon the Vegetable Oil Products Controller for India by Sub-clause (1) of Clause 4 of the V.O.P. Control Order, 1947, the Controller has issued from time to time the specifications to which all vegetable oil products must conform. The latest specifications were issued by him under a Notification of the Union Government in the Ministry of Agriculture dated the 21st of October, 1950, and the said Notification is reproduced below.

MINISTRY OF AGRICULTURE

NOTIFICATION

New Delhi, the 21st October, 1950.

S.R.O. 780.—In exercise of the powers conferred by Sub-clause (1) of Clause 4 of the Vegetable Oil Products Control Order, 1947, as continued in force by Sub-section (2) of Section 17 of the Essential Supplies (Temporary Powers) Act, 1946 (XXIV of 1946), and in supersession of the Notification of the Government of

** Substituted for the words "His Majesty" by S.R.O. 952 dated 25-11-1950.
£ Added by S.R.O. 952 dated 25-11-1950.
££ Added by S.R.O. 2040 dated 22-12-1951.
§ By various notifications, the V. O. P. Controller has delegated these powers to a large number of State Government officials, mainly in the Civil Supplies, Health and Food Departments.

India in the Department of Food No. 5-VP (1)/47 dated the 31st January, 1947, the Vegetable Oil Products Controller for India hereby prohibits the manufacture, stock or sale of any vegetable oil product which does not conform to the following provisions, namely :—

*1. It shall be prepared by hydrogenation from only such edible harmless vegetable oils @ or mixtures thereof as are permitted by the Vegetable Oil Products Controller for India.

2. It shall not contain any harmful colouring, flavouring or any other matter deleterious to health.

3. No colouring shall be added to it unless with the prior sanction of the Vegetable Oil Products Controller and in no event any colour resembling the colour of ghee.

4. If any flavour is used, it shall be distinct from that of ghee in accordance with a list of permissible flavours and in such quantities as may be prescribed by the Vegetable Oil Products Controller for India.†

5. It shall not have moisture exceeding 0·25 per cent.

§6. The melting point as estimated by the capillary slip method (as described in Note I below) shall be from 33°C to 37°C, both inclusive.

7. The Butyro Refractometer reading at 40°C shall not be less than 48.0.

8. It shall not have unsaponifiable matter exceeding 1.25 per cent.

9. It shall not have free fatty acids (calculated as oleic acid) exceeding 0.25 per cent.

10. The product on melting shall be clean and clear in appearance and shall be free from sediment and rancidity and pleasant to taste and smell.

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* Amended by S.R.O. 3214 dated 1-10-1954.

@ By his letter No. 4-VP(1)/54 dated 7-12-1954, the V.O.P. Controller has declared (1) groundnut oil, (2) cottonseed oil and (3) sesame oil as the oils permitted for the manufacture of vegetable oil products under the above clause.

† By his letter No. 5-VP(1)/50 dated 2-8-1950, the V.O.P. Controller permits the following flavouring ingredients to be used in vegetable oil products, either singly or in combination, but in a total quantity of not less than 25 parts per million :—

1. Ethyl butyrate
2. Ethyl caproate
3. Iso-propyl butyrate
4. Ethyl caprilate
5. Coumarin (deleted by Notification No. 5-VP(4)/53 dated 28-10-1953)
6. Vanillin
7. Benzaldehyde
8. Amyl acetate.

§ The V.O.P. Controller has agreed in principle to grant permission to individual factories to manufacture vegetable oil products with a melting point of 31° C for despatch to specified stations during the winter. Also, by his letter No. 5-VP(5)/52 dated 26-5-1952, the V.O.P. Controller permits the manufacture of vegetable oil products with a melting point of upto 41°C for sale to biscuit manufacturers only.

11. It shall contain raw or refined sesame (til) oil not less than 5 per cent by weight but sufficient so that when the vegetable oil product is mixed with refined groundnut oil in the proportion of 20:80, the red colour produced by the Baudouin test (as described in Note II below) shall not be lighter than 2.0 Red units in a 1 cm cell on the Lovibond scale.

12. It shall be manufactured in premises maintained under hygienic conditions.

†13. All vegetable oil product manufactured on or after the 1st of December, 1953, shall contain not less than 700§ I.U. of synthetic vitamin A per ounce of vegetable oil product.‡

Note I—*The Capillary Slip Method*

(*i*) Thin walled glass tube open at both ends with an external diameter of 1.2 to 1.5 mm and internal diameter of 0.83 to 1.1 mm and length 5 to 6 cm should be used after proper cleaning and drying.

(*ii*) The sample of the vegetable oil product should be completely melted and well mixed at a temperature of about 50°C. The capillary tube should be inserted into the molten product so that a column of the product about one cm long is forced into it. The sample in the tube should be allowed to just set by keeping the tube in a horizontal position during winter, and during summer the tube may be put on a perforated metal tray which is so placed inside a small water bath containing water at 15°—17°C that the bottom of the tray just touches the water.

(*iii*) The tube is then placed in a test tube immersed in water at 15°-17°C for one hour.

(*iv*) A centigrade thermometer (reading in 1/5th of a degree) should be suspended in the centre of a beaker provided with side tube heating arrangement so that the lower end of the sample column is 3 cm below the surface of water.

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† Inserted by S.R.O. 2103 dated 9-11-1953.

§ Increased from 300 to 700 I.U. per ounce for all vegetable oil products manufactured on or after 1-5-1955 (S.R.O. 924 dated 30-4-1955).

‡ For the time being, there is only an indirect control through proper returns on the incorporation of vitamin A in vanaspati. The V.O.P. Controller's letter No. 5-VP(4)/53 dated 21-12-1953 reads as under :

"I am directed to invite a reference to Government of India Notification No. S.R.O. 2103 dated 9-11-1953 whereby all vanaspati manufactured on or after 1-12-1953 is required to contain not less than 300 I.U. of synthetic vitamin 'A' per ounce and to say that the degree to which potency of vitamin 'A' goes down in processing and in storage is, under investigation and the details of the method to be prescribed for assaying vitamin 'A' are to be finalised shortly. It would, therefore, not be proper to launch prosecution against any factory on the basis of samples found deficient in vitamin 'A' until the above details have been worked out and a suitable method prescribed for vitamin 'A' estimation. As an interim measure it is proposed to enforce the provisions of the notification referred to above by physical checking of the stocks of vitamin 'A' at different factories.

You are, therefore, requested not to launch prosecution against any factory for deficiency in vitamin 'A' content till further communication from this office."

After the amendment of Clause 13 by S.R.O. 924 dated 30-4-1955 increasing the incorporation of vitamin A to 700 I.U. per ounce, the V.O.P. Controller wrote again (No. 4-VP(2)/55/3849 dated 20-7-1955) to all State Governments repeating the instructions contained in the letter reproduced above.

The initial temperature of the water should be 20°C. The side tube of the apparatus should be heated gently, so that the temperature of water increases slowly at the rate of 2°C per minute till the temperature reaches 30°C, and thereafter at the rate of ½ a degree per minute.

(*v*) The temperature of water should be noted when the sample column commences to rise in the tube. This temperature is recorded as the melting point.

The thermometer used in this test should be checked against a standard thermometer calibrated and certified by the National Physical Laboratory, Teddington, England.

Note II—*The Baudouin Test*

(*i*) Reagents to be used:

(1) Refined (neutralised and bleached) groundnut oil of light colour showing a negative Baudouin test.

(2) Concentrated hydrochloric acid (A.R.) solution (Sp. gr. 1.19 at 15.5°/15.5°C) containing not less than 37% HCl by weight.

(3) Furfurol, which has been distilled within 24 hours prior to the test, dissolved in alcohol of not less than 95% strength to give a 2% solution (v/v).

(4) Chemically pure dilute hydrochloric acid solution (Sp. gr. 1.125 at 15.5°/15.5°C) containing 24.75% HCl by weight.

(*ii*) The Procedure:

The sample of the vegetable oil product should be completely melted and well mixed at a temperature of about 50°C.

(*a*) Carry out a test for the presence of colouring matters which are chromogenic in the presence of hydrochloric acid as given in (*b*) below.

(*b*) Shake 10 cc of the melted vegetable oil product with 10 cc of concentrated hydrochloric acid (reagent 2 above). If there is no development of a red colour in the aqueous layer, apply the Baudouin test as described in (*d*) below. If a red colour develops in the aqueous layer, proceed as in (*c*) below.

(*c*) Shake 15 cc of the melted vegetable oil product in a separating funnel for half a minute with 15 cc of dilute hydrochloric acid (reagent 4 above). During the treatment do not permit the temperature of the contents of the separating funnel to exceed that necessary to keep the sample in a liquid condition. Draw off the red acid layer which collects at the bottom of the funnel and repeat the process until no further colouration takes place. After the hydrochloric acid layer has been completely removed, apply the Baudouin test to the vegetable oil product so obtained, as described in (*d*) below.

(*d*) The Baudouin test shall be carried out as follows:—

1. Dilute 10 cc of the melted vegetable oil product to be tested with 40 cc of refined groundnut oil (reagent 1).

2. Take 5 cc of this mixture in a 25 cc measuring cylinder with glass stopper and add 5 cc of concentrated hydrochloric acid (reagent 2).

3. Add 0.4 cc of the alcoholic solution of furfurol (reagent 3).

4. Shake vigorously for 2 minutes.

5. Allow to stand for 5 minutes.

6. Filter the contents of the measuring cylinder through a wet filter paper.

7. Determine the red colour of the filtrate and express the colour reading in terms of R (Red) units on the Lovibond scale as obtained by using a 1 cm cell.

8. Perform a blank experiment by using 5 cc of refined groundnut oil (reagent 1) in place of 5 cc of mixture of vegetable oil product and refined groundnut oil and determine the colour on Lovibond scale as under 7 above.

9. Deduct the colour reading obtained under 8 from that obtained under 7 and record as the Baudouin test of the sample.

Note: The time elapsing between the addition of the furfurol solution and the reading of the colour should not exceed 12 minutes.

DIRECTIONS ISSUED UNDER CLAUSE 5(1) OF THE VEGETABLE OIL PRODUCTS CONTROL ORDER

In exercise of the powers conferred upon the Vegetable Oil Products Controller for India by Sub-clause (1) of Clause 5 of the V.O.P. Control Order, 1947, the Controller has been issuing from time to time directions regarding the stock and sale of Vegetable Oil Products by dealers. The relevant notifications are given below.

(I)

MINISTRY OF AGRICULTURE

NOTIFICATION

New Delhi, the 30th day of July 1949.

No. 5-VP(2)/49—In pursuance of Sub-clause (1) of Clause 5 of the Vegetable Oil Products Control Order, 1947, and in suspersession of the Notification of the Government of India in the Ministry of Agriculture, No. 5-VP(2)/49 dated the

1st June 1949, the Vegetable Oil Products Controller for India hereby directs that—

I. (1) every container in which a vegetable oil product is packed shall at the time of the sale by the producer *(or any dealer) bear the name of the producer, and the words 'Hydrogenated Groundnut Oil' or 'Hydrogenated Groundnut and Cottonseed Oil' or 'Hydrogenated Groundnut and Cocoanut Oil', as the case may be **(or made from Vegetable Oils only) marked in capital letters not less than half an inch high in English and the equivalent of the same in one or more vernacular languages @ in such a manner as to be plainly visible to any purchaser; and

(2) the words "Vanaspati" and "Vegetable Product" or any words equivalent thereto shall not be used or shown on such containers to denote the contents thereof.

II. Clause (1) of paragraph I shall come into force on the 1st day of August, 1949; but clause (2) of paragraph I shall take effect only from such date as the Vegetable Oil Products Controller for India may, by notification in the Official Gazette, appoint in this behalf.

N. T. MONE
Vegetable Oil Products Controller for India.

(II)

MINISTRY OF AGRICULTURE

NOTIFICATION

New Delhi, the 23rd December 1950.

S.R.O. 1090.—In pursuance of Sub-clause (1) of Clause 5 of the Vegetable Oil Products Control Order, 1947, and in supersession of the Notification of the Government of India in the Ministry of Agriculture No. 5-VP(2)/49, dated the 10th December, 1949, the Vegetable Oil Products Controller for India hereby notifies the following directions regarding the stocking and sale of vegetable oil products by dealers :—

1. No dealer in any vegetable oil product shall stock or sell animal ghee in the premises where the vegetable oil product is stocked or sold.

2. Every dealer in a vegetable oil product shall display a signboard, in a prominent place in the premises where the vegetable oil product is sold so as to be clearly visible to a purchaser indicating in one or more languages

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* Inserted by Notification No. 5-VP(2)/49 dated 1-10-1950.
** Inserted by S.R.O. 835 dated 5-3-1954.
@ By his letter No. 5-VP(6)/54/1755 dated 1-4-1954, the V.O.P. Controller has prescribed the Hindi equivalent for the phrase 'Made from Vegetable Oils only' as "Keval Vanaspati telon se Banaya Hua."

of the locality that "Hydrogenated Groundnut Oil" (Mungphali Ka Jamaya Tel) or "Hydrogenated Groundnut and Cocoanut Oil" (Mungphali Aur Narial Ka Jamaya Tel) or "Hydrogenated Groundnut and Cottonseed Oil" (Mungphali Aur Binaula Ka Jamaya Tel), as the case may be, is sold in the premises.

3. Every dealer in a vegetable oil product shall exhibit in a prominent place in the premises where vegetable oil product is sold, a list of prices (wholesale or retail as the case may be) as fixed by the Vegetable Oil Products Controller for India from time to time (entire clause deleted by S.R.O 1240 dated 19-7-1952).

4. It shall be the duty of every dealer to insure that every container in which vegetable oil product is packed shall at the time of the sale bear the month and year of manufacture. The date may be marked on the container either by means of a rubber stamp or by embossment.

5. The provision of Clauses 1, 2 and 3 shall come into force at once and the provision of Clause 4 shall take effect from 1st January, 1951.

N. T. MONE
Vegetable Oil Products Controller for India.

(III)

No. 5-VP(4)/51

OFFICE OF THE VEGETABLE OIL PRODUCTS CONTROLLER FOR INDIA GOVERNMENT OF INDIA, MINISTRY OF FOOD AND AGRICULTURE

"JAMNAGAR HOUSE"

New Delhi, the 3rd April, 1951.

To

All Vegetable Oil Product Factories

Subject:—Addition of Vitamins in Vegetable Oil Products

In supersession of this office Circular Letter No. 5-VP(4)/50 dated the 5th December, 1950, it has been decided that any factory which claims its product to be vitaminised shall invariably show from 1-5-1951 onwards the name of the vitamin added ('A' & 'D') on the labels. It should, however, be noted that no manufacturer can claim its product as containing the specified vitamin unless the quantity added is not less than 300 I.U. of vitamin 'A' per ounce and 50 I.U. of vitamin 'D' per ounce in vanaspati.

N. T. MONE
Vegetable Oil Products Controller for India.

(IV)

OFFICE OF THE VEGETABLE OIL PRODUCTS CONTROLLER FOR INDIA GOVERNMENT OF INDIA, MINISTRY OF FOOD AND AGRICULTURE

"JAMNAGAR HOUSE"

New Delhi, the 21st March, 1953.

To

All Vegetable Oil Product Factories

ORDER

In exercise of the powers conferred by Clause 5(1) of the Vegetable Oil Products Control Order, 1947, as subsequently amended by the Central Government in the Ministry of Food and Agriculture Order No. S.R.O. 71 dated the 10th January 1953, I, M.R. Bhide, Vegetable Oil Products Controller for India hereby direct you to maintain with effect from 1st April, 1953, the record of Baudouin test of each batch of vanaspati produced by you in your factory in the form given in the schedule annexed hereto and make such records available for inspection as and when required by any person duly authorised in this behalf.

M. R. BHIDE
Vegetable Oil Products Controller for India.

SCHEDULE

NAME OF FACTORY .....

Serial No.	Date	Serial Batch Number of the month	Quantity represented by the Batch Number	Baudouin Test Reading of the Batch (in figures and words)	Signatures of the Chemist certifying the correctness of the entries in Cols. 1 to 5
(1)	(2)	(3)	(4)	(5)	(6)

Note : 1. All the entries made in the register shall be in ink.
2. No erasing shall be allowed in the entries made in the register.
3. Any amendment or alteration to be made shall be in red ink and shall be attested by the Chemist concerned.

Appendix D

A.S.C. SPECIFICATION NO. 139 (N.S.) FOR OIL HYDROGENATED

(Issued on 20-2-1956)

1. **Quality**

(*i*) The oil hydrogenated shall be prepared from refined oils. It shall be granular and suitably flavoured. It shall contain diacetyl as one of the constituents of the flavour used. No colouring shall be added.

(*ii*) The oil hydrogenated shall be produced from any edible harmless vegetable oils or mixtures thereof. All oils used for hydrogenation shall be approved by the Director of Supplies and Transport.

Note : The oil hydrogenated in all cases shall contain unhydrogenated, raw or refined sesame (til) oil not less than 5 per cent by weight but sufficient to respond to the Baudouin test, as described in para 6 below, the red colour produced being not lighter than 2.0 Red units in a 1 cm cell on the Lovibond scale.

(*iii*) The oil hydrogenated shall be clean and wholesome, free from mineral, marine and animal oils, and in all respects suitable for human consumption.

(*iv*) When melted the oil hydrogenated shall be clean, clear, free from sediment and rancidity and pleasant to taste and smell.

(*v*) The oil hydrogenated shall contain not less than 700 I.U. of synthetic vitamin A per ounce.

2. **Packing**

(*a*) *Tins.* The oil hydrogenated shall be packed in hermetically sealed four gallon K. O. type narrow mouthed tins made from bright new tin plates conforming to Drawing No. IND/GS/FD/2.* The nett contents of each tin shall be 36 lbs.

(*b*) *Cases.* When cased supplies are ordered, the tins shall be packed in strong wooden cases conforming to Specification No. IND/GS/FD/2(d) Size 1.* Each case shall contain two tins.

3. **Marking**

(*a*) *Tins.* Each tin shall be printed, lithographed or stencilled with the following particulars :—

(*i*) Description of contents (any oil constituting more than 5 per cent of the product shall be clearly indicated on the containers).

(*ii*) Name of manufacturer.

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* Not reproduced in this Appendix.

(*iii*) Month of manufacture.

(*iv*) Nett weight of contents.

(*v*) Warranty period.

(*b*) *Cases.* The following particulars shall be stencilled on one side of each packing case :—

(*i*) Description of contents.

(*ii*) Gross weight.

(*iii*) Number of tins.

(*iv*) Name of manufacturer.

(*v*) Month of manufacture.

(*vi*) Expiry of warranty.

(*vii*) Number and date of acceptance of tender.

The ends of each packing case shall be marked with an equilateral triangle of 4" dimensions in green or black paint, the triangle being so placed as to indicate the top of the case with its apex.

4. Warranty

In accordance with the Standard Warranty Clause (Appendix I*), the warranty period being six months.

5. Hygiene

The oil hydrogenated shall be manufactured in premises maintained in a hygienic condition which shall be open to inspection at any time by a competent authority approved by the Quarter-Master General and the Director of Medical Services.

The hygiene requirements in a factory producing the oil hydrogenated shall be in accordance with Appendix II.*

6. Inspection

An inspection shall be carried out by the Director of Supplies and Transport (or an officer acting on his behalf) on all supplies tendered for acceptance. The decision of this officer shall be final.

The oil hydrogenated shall conform to the following analysis :

(*a*) Moisture — Not more than 0.25%

* Not reproduced in this Appendix.

(*b*)	Free fatty acids (calculated as oleic acid)	Not more than 0.25%
(*c*)	Melting point as determined by the capillary tube method	37°C±2°C
(*d*)	Butyro Refractometer reading at 40°C	Not less than 48.0
(*e*)	Unsaponifiable matter	Not more than 1.25%

(*f*) The oil hydrogenated shall contain diacetyl sufficient to respond to the test given below but not more than 4 parts per million.

The methods of analysis used shall be those laid down by the latest edition of the Association of Official Agricultural Chemists (A.O.A.C.), except for Baudouin test and the test for diacetyl which shall be carried out as follows :—

(A) *Baudouin test :*

Place in a test tube 5 cc of the sample (20 parts of vegetable oil product and 80 parts of refined groundnut oil) and 5 cc of hydrochloric acid (specific gravity 1.19) and add to it 8 drops of a 2 per cent solution in alcohol of freshly distilled furfurol, shake vigorously for 2 minutes and allow to stand. The acid layer becomes distinctly red. Quickly filter the acid layer through a wet filter paper and examine the filtrate against a Lovibond scale in a 1 cm cell or against a red colour comparator.

If the vegetable oil product on being shaken with hydrochloric acid alone, conveys a redness to the hydrochloric acid owing to the presence of certain artificial colouring agents, the procedure will be as follows :—

Shake 10 cc of melted vegetable oil product in a separating funnel for half a minute with 10 cc of hydrochloric acid (specific gravity 1.125). Draw off the red acid layer which collects at the bottom of the funnel and repeat the process until no further colouration takes place. During the treatment, do not permit the temperature of the contents of the separating funnel to exceed that necessary to keep the sample in a liquid condition. After the hydrochloric acid has been completely removed, apply the Baudouin test as described above.

(B) *Test for Diacetyl :*

Weigh 500 grams of the sample into a litre flask fitted with ground glass stopper having two tubes arranged for steam distilation. Add to the flask 75 cc of 0.1N sulphuric acid and enough salt to saturate the solution. Connect the flask to a steam generator and to an upright condenser by means of a Polenske trap or other trap attachment. Keep the flask in an oil bath maintained at 115°-120°C. The tip of the condenser should dip into a mixture of 4 cc of 20 per cent hydroxylamine hydrochloride, 4 cc of 20 per cent sodium acetate and 2 cc of 5 per cent

nickel sulphate. Steam distil until 150-200 cc of distillate is collected, stirring the mixture in the receiver occasionally. Evaporate the distillate on a steam bath at 80°C until the volume is reduced to about 10 cc. Allow to stand and cool. Transfer the contents to a separating funnel.

Wash the receiver twice with 5 cc portions of water. Extract the nickel dimethyl-glyoxime with 15 cc of chloroform. Wash the receiver with chloroform before it is added to the separating funnel. Repeat extraction with three successive portions of 10 cc of chloroform, washing with each portion the receiver before adding to the separating funnel. The chloroform extract is drawn off through a small filter to a glazed evaporating basin every time. At the end, the filter is washed with 5 cc of chloroform. Evaporate the combined chloroform extracts on a water bath at low heat. Nickel dimethyl-glyoxime with its characteristic pink colour will be precipitated as a thin layer inside the basin. For quantitative determination, the precipitate obtained above is dried for one hour at 100°-105°C, cooled and weighed.

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